STAFFORDSHIRE UNIVERSITY
SCHOOL OF LIFE SCIENCES AND EDUCATION
UNITED KINGDOM

The Development of Seychellois Primary School Teachers' Mathematical Knowledge for Teaching and Self-Efficacy Beliefs through Reflective Practice: A Quasi-experimental Study

Bryan George Moumou

August 2021

A thesis submitted in partial fulfilment of the requirements of Staffordshire University for the award of the degree of Doctor of Philosophy

Declaration

I declare that this thesis is my own work and original report of the research. I confirm that this work has not been submitted for any other degree.

Signed: *Bryan Moumou*

Abstract

Primary school pupils in Seychelles are underperforming with low standards of proficiency in mathematics, relative to local and international benchmarks. There are concerns that primary school teachers might not have the appropriate Mathematical Knowledge for Teaching (MKT) nor confidence to teach mathematics. While it is widely accepted that MKT, and self-efficacy beliefs that assist the development of MKT, are important for effective teaching, less is known about how they are enhanced through reflective practice (RP). Enhancing teachers' MKT and self-efficacy beliefs is important because these have been connected to pupils' achievement. This mixed-methods research explores to what extent the MKT sub-domains, MKT self-efficacy beliefs, and Mathematics Teaching Self-efficacy (MTSE), of seventeen in-service primary school teachers, in the areas of number concepts, number operations and word problem solving, are enhanced through RP. Using a pragmatic approach, this multiple case study integrates inductive designs and quasi-experimental methodologies to analyse reflective journals, semi-structured interviews, pre-post-tests, and pre-post questionnaire surveys, within an interpretivist paradigm. Independent-samples t-test, Paired-samples t-test, Cluster analysis, and Difference in Differences (DiD) methodology were used to analyse the quantitative data. The qualitative data were analysed thematically. This study employed Desimone's professional development framework, Mezirow's transformative learning theory (TLT), and the social-constructivist theory as conceptual and theoretical lenses respectively to frame this research. Analysis of the quantitative data revealed that there were no statistically significant differences between the intervention group and the control group in their MKT sub-domains and MTSE. However, the DiD estimator showed that the intervention group had a systematic increase in both their MKT sub-domains and MTSE levels through RP. On the other hand, there was statistically significant difference in the MKT self-efficacy beliefs between the intervention and control groups. Seven themes wove through the teachers' 'stories', thus supporting positive influence of RP on MKT sub-domains, MKT self-efficacy, and MTSE of the teachers. Merging the qualitative and quantitative evidence indicated that the ten weeks of RP of the teachers started to have positive effects on their MKT and self-efficacy beliefs; not identified in previous studies. The teachers expressed positive change in their MKT and self-efficacy beliefs pertaining to the teaching of word problem solving strategies. Nevertheless, the results also demonstrated that educational change is difficult and requires commitment and time. This research makes two original contributions to knowledge. Firstly, to the MKT literature through a proposed framework for teachers' MKT growth through RP. Secondly, to Bandura's sources of efficacy theory through a typology of teachers' self-efficacy growth through RP. The findings of this study are proposed as frameworks for teachers' professional growth in the context of Seychelles and also in Small Island Developing States (SIDS).

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Acronyms, Abbreviations and Definitions

Throughout this thesis, the following acronyms and abbreviations are used:

CBMS	Conference Board of the Mathematics Sciences
CCK	Common Content Knowledge
CCATS	Centre for Curriculum, Assessment and Teacher Support
CA	Cluster Analysis
DiD	Difference in Differences
IGCSE	International General Certificate of Secondary Education
IMF	International Monitory Fund
KCS	Knowledge of Content and Students
KCT	Knowledge of Content and Teaching
KC	Knowledge of Curriculum
LD	Learning Disabilities
MTSE	Mathematics Teaching Self-efficacy
MOE	Ministry of Education
MKT	Mathematical Knowledge for Teaching
MCK	Mathematical Content Knowledge
OECD	Organisation for Economic Co-operation and Development
PD	Professional Development
PIES	Picture, Information, Equation, Solution
PIRLS	Progress in International Reading and Literacy Study
PGCE	Post Graduate Certificate in Education
PCK	Pedagogical Content Knowledge
PISA	Programme for International Student Assessment
PD	Professional Development
PSST	Pre-service Student Teacher
PST	Pre-service Teacher
P6	Primary 6
RP	Reflective Practice

SITE	Seychelles Institute of Teacher Education
SIDS	Small Island Developing State
SMK	Subject Matter Knowledge
SPSS	Statistical Package for the Social Sciences
SCK	Specialised Content Knowledge
SACMEQ	Southern and Eastern Africa Consortium for Measuring Education Quality
TLT	Transformative Learning Theory
TIMSS	Trends in International Mathematics and Science Study
TALI	Teaching and Learning International Survey
TA	Teaching Assistant
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UK	United Kingdom
UN	United Nations
USA	United States of America

Mathematical Knowledge for Teaching (MKT): the mathematical knowledge required to effectively implement the work of teaching mathematics (Ball et al., 2008).

Mathematical Knowledge for Teaching Self-efficacy (MKT Self-efficacy): teachers' judgement of their capabilities to use their MKT to improve the learning outcomes of their pupils in a content area, especially those facing difficulties.

Mathematics Teaching Self-efficacy (MTSE): teachers' judgement of their capabilities towards mathematics teaching in a content area, especially those facing difficulties.

SIDS: a group of **S**mall **I**sland **D**eveloping **S**tates confronting specific and common social, economic, and environmental susceptibilities.

Dedication

> *Mum, Daddy has left his 'Mentholatum' behind. What if he gets sick in the UK?*
>
> (Nigella, 2014)

I dedicate this doctoral work to my family. The above words were from my six-year-old daughter to her mother in 2014, when I left for the UK to start my PhD journey. While I was there in the UK starting the PGCRM programme, back in Seychelles my wife gave birth to my son Aleron. Therefore, I dedicate this work to my five-year-old son Aleron, my eleven-year-old daughter Nigella and my wife Yvonne. In pursuing this study, I have challenged them to take their education seriously, develop a love for learning, and follow in the steps of their father.

Acknowledgements

I take this opportunity to thank all those who have helped me in one way or another during the process of conducting this research. Firstly, I would like to thank Jesus Christ for offering me ‘HIS mercy and grace to help in time of need' (Hebrews 4:16), especially when I felt alone and did not know what to write. Secondly, I would like to thank the government of Seychelles for sponsoring my study, as well as funding my stay in the UK. Thirdly, I would like to thank my supervisors and the Education Institute staff at Staffordshire University who have helped and supported me to bring this study to completion; as well as making my stay in the UK comfortable. A special thank you goes to Associate Professor Gillian Forrester and Dr. Claire Kinsella who have been extremely supportive of my work through their patience, professional insights, invaluable comments, and thoughtful and critical feedback on the various drafts of my work. My sincere gratitude also goes to my past supervisors Professor Tehmina Basit and Dr. Claire Stanier who believed in my ability to undertake this study and gave me their support and guidance.

I am also indebted to all the ‘Seychellois’ primary school teachers whose participation and stories made this research possible. Last, but not least, I would also like to thank my wife for her support and motivation.

Preface

> *Sir, the maths test you gave is a bit challenging. However, there is one test question I want to improve myself on because the teaching of mathematics is becoming more difficult. Maths has been a problem for some time, so. Even the Minister has been saying in the national assembly that maths is a problem. So, what do we do when there is a problem? We need to get the help as teachers if we need it. Also, the pupils are not motivated to go the extra mile to improve themselves.*
>
> [**Vignette**, Interview]

This thesis begins with a reflective preface on how the topic of this research gained my personal and professional interest. This study explores the effects of Reflective Practice (RP) on the Mathematical Knowledge for Teaching (MKT) sub-domains, MKT Self-efficacy and Mathematics Teaching Self-efficacy **(**MTSE) beliefs of primary school teachers in Seychelles.

Clough and Nutbrown (2012) state that researchers should consider and explain the motivational factors that influence their research. The history of my love of mathematics and the desire to conduct this study stems back to my childhood and goes back to my early school experiences with mathematics – an important determinant of my current, personal philosophy, thinking and attitude towards mathematics and research. However, my interest in this research is also rooted in my background as a mathematics teacher and teacher trainer. In 1990, I returned to Seychelles from Sussex University (UK) with a Bachelor’s degree in mathematics education and started teaching mathematics in a National Youth Service school. Then, with the changes in the teaching of mathematics over the years, in 2002 I decided to further my mathematics teaching knowledge by embarking on a Master’s degree course in mathematics education at Edith Cowan University (ECU) in Australia. These qualifications provided me with more confidence and knowledge to teach mathematics to both pupils and adults and to train mathematics teachers; as well as providing me with a renewed personal philosophy of mathematics teaching and learning. That is, as a positive turning point (Guillaume and Kirtman, 2010), it produced a dramatic shift in my philosophical perspective as to what is mathematics, how it should be taught, and how to be an effective mathematics teacher. Since then, for more than two decades, I have been involved with the teaching of mathematics and training of mathematics teachers at the School of Education. In 2014, I joined the University of Seychelles, initially to develop and run a local Bachelor’s degree course in mathematics education, and then onto my current role as Head of the Education Department.

My mathematics journey as a student and now a university lecturer has been tainted by my early and frustrating experiences of traditional mathematics learning through rote memorisation of mathematics algorithms and formulae, with little understanding, which was not a reflection of my inability. My mathematics story as a student is predominantly characterised with episodes of success and failure, rooted in the behaviourist theories. However, I have always found mathematics exciting and interesting.

In the past thirty years, through the publication of various national reports, and the implementation of various educational policies and reforms by the Ministry of Education, I see little progress in the attempts to improve mathematics education for Seychellois students. My curiosity motivates me to understand and to find solutions as to why, after so many years of teacher training, the teaching and learning of primary mathematics is still an issue in Seychelles. Eventually, the years of underachievement in mathematics by Seychellois students got my professional attention, and the ongoing, unproductive struggles of my daughter with mathematics stimulated my interest in researching in the area of mathematical knowledge of teachers. Even during the collection of data for this research I met teachers who told me that they still do not fully understand the mathematics that they are teaching (Ball et al., 2005; Wu, 2018), but would not want to give up. Therefore, the focus of this research, and the reason for conducting this study, stem from the aforementioned experiences and concerns; and the aim is to provide a solution to the challenges facing mathematics education in Seychelles. As a mathematics educator, I have the unwavering responsibility to help both teachers and students learn mathematics. I wanted to see whether the mathematical knowledge for teaching of teachers (Ball et al., 2008) can be improved on so that there can be a positive change in the mathematics learning outcomes of students in Seychelles.

Hence, this study has been developed as a frustrated response to the country's mathematics education crisis as exemplified in the above excerpt from **Vignette**. For example, the primary six national mathematics examination means for 2018 and 2019 were 43% and 44% respectively (see Table 2.2); thus, a persistent low trend (CCATS, 2018; 2019). For the past two decades the schools have been experiencing low outcomes in their mathematics achievement, with substantial variation in the scores (see Tables 2.1 and 2.2). Being a Small Island Developing State (SIDS), Seychelles is plagued by several development challenges and constraints common to SIDS.

This thesis is the culmination of six years of study, and this reflective preface provides a record of the journey. The research journey was heavily imbued with the attempt to address the immutable problem of mathematical underachievement of primary school pupils in Seychelles. It later gained much more momentum with the desire to improve the MKT of one of my daughter's primary mathematics teachers. My interest was increased by the lack of MKT of that teacher after she gave my daughter an incorrect formula for the circumference of a circle (e.g. $C=2\pi d$ instead of $C=2\pi r$). It then became clear to me that teachers' knowledge has a significant influence on pupils' learning and achievement (Harnett, 2012). Moreover, such a mistake reminds me that it takes more than just being able to solve most mathematics problems in the school textbook to declare oneself a mathematics teacher. This gave me the desire to learn more about the thoughts and actions of teachers, in terms of reflection and change in their MKT.

In recent decades, most of the pre-service teachers entering their initial teacher training in Seychelles have had limited Mathematical Content Knowledge (MCK). The mathematics teaching entry requirements for primary school teacher training in Seychelles is a 'C' grade in mathematics at IGCSE level. This is alarming because, surely, teachers must know the subject they teach (Ball et al., 2008; Wu, 2018). Reid and Reid (2017) explain that teachers need a solid MCK base in order to support the pupils' achievements. In 2016 and 2018, I was involved in programmes to upgrade the MCK of primary teachers up to Advanced Level (Cambridge A Level) standard because most of their mathematics results were very weak. Such a lack of MCK has an adverse effect on their Pedagogical Content Knowledge (PCK) (Shulman, 1986; Ball et al., 2008; Thames and Ball, 2010; Reid and Reid, 2017; Kuennen and Beam, 2020); thus, hindering the teachers' ability to effectively teach mathematics. At the outset of this PhD journey, I wanted to quantitatively address the issue of underachievement in primary mathematics by revealing patterns in the educational data of pupils through a data-mining approach. This would have perhaps made the study purely quantitative and provided limited knowledge, while not necessarily improving existing knowledge, policy, and practice (Basit, 2010). Then, reflecting on the issues my daughter was having with mathematics, I began to consider how the MKT of those teachers could be enhanced. I understood that various educationalists (e.g. Lee, 2005; Deacon, 2012; Töman, 2017) have revealed and agreed that most initial teacher education programmes can no longer effectively prepare teachers to teach the upcoming generation of pupils.

Reflective teacher education was then seen as a potential solution because it allows teachers to continually self-examine and self-evaluate in order to improve their professional knowledge. However, it did not take long to realise the non-existence of any practice of formal reflection in teachers' initial training in Seychelles. Even though RP has been the norm in many countries (Cropley et al., 2010; Bawaneh et al., 2020), it is given far less attention in Seychelles. To the best of my knowledge, there have not been any studies dealing with the RP of in-service primary mathematics teachers in Seychelles. This issue therefore has influenced and guided my thoughts towards this exploratory research and acted as an impetus for this study. Therefore, the thesis statement of this study is that the poor or lack of practice of formal reflective teaching by the teachers, and the alleged weaknesses in their MKT could contribute to the underachievement of pupils in mathematics. Since Widodo and Ferdiansyah (2018) explained that teachers' experiences do not guarantee improvement of practice, RP has been getting considerable attention. Thus, developing teachers' MKT through RP could lead to possible improvement in their teaching of mathematics.

Several recent and seminal studies have claimed that teachers' knowledge of mathematics somehow correlates with pupils' achievements (e.g. Hill et al., 2005; Odumosu and Fisayi, 2018). Hence, one of the arguments being advanced in this study is that the mathematical achievement of pupils in the primary schools of Seychelles can only improve if teacher quality is improved (Ishola and Udofia, 2017). Such a contention is based on the assumption that some teachers might not be effective (Hattie, 2009). Hattie (2012) suggests that teachers who can reflect and appraise their practices are more likely to change the learning outcomes of their pupils. This agrees with Sellars (2012:461) who argues that the agents of change in education are "not the policy makers, the curriculum developers or even the education authorities", but the teachers. Therefore, this research is an attempt to improve the MKT of the teachers.

Chapter 1: Introduction

1.1 Background to the Research

The issues and concerns identified in the preface, and with the now growing international importance of Science, Technology, Engineering, and Mathematics (STEM) education in schools (Bergsten and Frejd, 2019), more than ever before, make primary mathematics an important subject to study. These concerns make this research very timely and pertinent. Internationally, large-scale studies (e.g. Yoon et al., 2007; Siegler et al., 2012) have shown that pupils' early achievement in mathematics is a strong predictor of their later achievement in other subjects, among them mathematics and reading. Context-wise, Yoon et al.'s work consisted of six, large, longitudinal developmental studies conducted in the United States of America (USA). Those studies were aimed at verifying whether school-entry achievement, attention, and socio-emotional skills were predictive of pupils' subsequent achievement. Results of rigorous regression analysis showed that school-entry mathematics was amongst the strongest predictors of pupils' future achievement. International organisations such as the Organisation for Economic Co-operation and Development (OECD) are working with governments of various countries to put in place "targeted policy advice to countries for improving the quality, equity and efficiency of learning opportunities", through the Programme for International Student Assessment (PISA) and the Teaching and Learning International Survey (TALIS) (OECD, 2017:24). In the USA, the Conference Board of the Mathematics Sciences (CBMS) is working with primary teachers to support them in developing the mathematical knowledge they would need to effectively teach (CBMS, 2012). With such intense international pressure, primary school teachers across the globe are now being held more accountable for equipping pupils with the necessary basic mathematics knowledge, skills and attitudes (OECD, 2018c). Nevertheless, international comparisons of several western countries continue to highlight the decline in mathematical performance of pupils (Fung et al., 2017; Norton, 2017). For example, within the United Kingdom (UK) a major proportion of pupils struggles with underachievement in mathematics without a disability diagnosis (Nelson and Powell, 2018); and this is in a country where basic mathematical skills are of high value in the labour market.

Being a Small Island Developing State, Seychelles has not been spared those sustainability and vulnerability issues common to SIDS, and which affect its education system. The challenge is to ensure quality primary education for all its citizens in order to keep its economy healthy and progressive. Despite the nation's economic growth, the basic educational performance of pupils in primary schools in Seychelles remains a major challenge. The country is experiencing several longstanding educational performance issues, such as the continuous failure of significantly large groups of pupils in primary mathematics, which have persisted for decades (CCATS, 2018; CCATS, 2019). Now, these issues are objects of national scrutiny (Seychelles Nation, 2017); and mathematics is being reported as one of the most problematic subjects in the Seychelles' national curriculum, and one in which pupils are underachieving (Leste et al., 2005; CCATS, 2018). It is unquestionable that persistent underachievement could have dire and lifelong consequences on both pupils and society. The researcher has witnessed how educational failures in schools in Seychelles have led to pupils dropping out of school; and those pupils (now adults) are abusing substances and experiencing both economic and social difficulties. And so, there is growing concern amongst academics, stakeholders in the education sector, and the media, fuelled by national and international examination reports, about the poor performance of pupils in primary schools. For example, in 2017 pupils who completed their final grade 6 national mathematics examinations obtained a low mean score of 39% compared to 50% in English, 56% in French, 42% in Science and 48% in Social Science (see Table 2.2). Both national and international assessments (e.g. SACMEQ (2005); CCATS, 2014; 2015; 2016; 2017; 2018; 2019), have reported the underperformance and low standards of proficiency in a number of subjects in Seychelles, mathematics being one of them, relative to local and international benchmarks. Several pupils in the Seychelles primary schools are still experiencing persistent low achievement in mathematics (CCATS, 2018). Mawanda (2016:1) made headline news with the words of the Minister of Education in the Today newspaper:

> *There is still much to be done to reach the level that the country wants to be at, to be able to offer quality of education. The investment that the government has done in education needs to translate into better results for the pupils.*
>
> (Today in Seychelles, 2016)

In a similar vein, Apple (2001:38) states that:

> *Public institutions such as schools are 'black holes' into which money is poured, and then seemingly disappears, but which does not provide anywhere near adequate results.*

Both of the above extracts are stating that policy reforms for schools are not being translated into noticeable results for the pupils, which could be interpreted as wasting of public resources. High investment in schools is usually followed by certain expectations from the investors.

One of the reasons for underachievement in most African countries and elsewhere has been the lack of qualified teachers in primary schools (International Mathematical Union, 2009). For example, in a study by Bold et al. (2017), they found roughly half of all second-grade pupils in Uganda cannot order numbers between 0 to 100, which they attributed to teacher quality. Even if Seychelles is not part of mainland Africa, it does not seem to have been spared the problems of under-qualified teachers in its primary schools. There are also concerns that primary school teachers might not have the appropriate practical knowledge and self-efficacy beliefs to teach mathematics, and therefore are not effective (Hattie, 2009; CCATS, 2018). Self-efficacy in teachers is a belief in their capability to implement appropriate actions that could change the learning outcomes of their pupils (Bandura, 1997). There is the argument that if teachers do not know enough about the mathematics they are teaching, they would not be able to organise their lessons to ensure effective teaching (Zhang and Stephens, 2013). However, no formal empirical research has been conducted to investigate such issues in Seychelles. Hence, developing the Mathematical Knowledge for Teaching (MKT) of primary teachers, in order to improve the pupils' performance, is seen as important by both local and global mathematics education communities.

Section 1.2 proposes a solution to the identified problem through the identification of gaps in the relevant literature. Following this, Section 1.3 presents the purpose of the research. Section 1.4 provides an overview of the methodology. Section 1.5 discusses the significance of the research. The penultimate section provides an overview of the thesis. Finally, Section 1.7 summarises the chapter.

1.2 Towards a Solution

Liston and Zeichner (1991) indicate that pedagogy has always been an issue when there is a call for reform in teacher practice. Similarly, Ball et al. (2005:14) argue that "… little improvement is possible without direct attention to the practice of teaching". The challenges facing the practice of primary mathematics teaching in Seychelles is three-fold. Firstly, pupils are underachieving in mathematics. Secondly, due to an acute teacher shortage, pupils are being taught using a large pool of untrained Teaching Assistants (TAs) who are products of the very system the policy makers are trying to fix. Thirdly, the MKT of current in-service primary teachers is, allegedly, weak; and around half the teachers in primary schools are uncertificated (Ernesta, 2018). Therefore, the researcher fervently argues that urgent professional-development measures are needed to upgrade the MKT of the current pool of primary teachers.

Nevertheless, despite the display of concern over underachievement in Seychelles' primary schools, there is a lack of research into its possible causes. Also, evidence suggests that primary school mathematics teachers in Seychelles have not been properly trained to take up the challenge of teaching primary mathematics and preparing pupils for the 21st century (e.g. CCATS, 2014; 2015; 2016; 2017; 2018; 2019). Very often the pre-service graduates enter the teaching profession with poor MKT, and hang tightly to their own understanding of mathematics, their experiences, and attitudes (Nason, Chalmers and Yeh, 2012). The view is also that some of the primary school teachers in Seychelles are "the graduates of the very system that we seek to improve" (Ball et al., 2005:14).

Internationally, mathematics education pedagogy has shifted teaching and learning away from the traditional behaviourist approach to a more engaging and adaptive style of teaching which incorporates ideas that pupils themselves raise in the class, as opposed to the traditional, strict delivery of pre-planned lessons (Sherin, 2002). However, in Seychelles, it is unrealistic to expect inexperienced or poorly trained teachers to use more advanced teaching skills. There also seems to be a culture of practice where teachers revert to behaviouristic, pre-planned mathematics lessons because they lack confidence in their own knowledge, which, in turn, leads to lack of flexibility in their response to their pupils. On the other hand, improving the pedagogical knowledge of primary teachers in Seychelles could be a lengthy process. Therefore, in the absence of further and proper training, rather than providing teachers with more content knowledge (Ball et al., 2005) they could enhance their MKT by "learning in the act of teaching" (Sherin, 2002:120). This can happen through ongoing professional development (PD) where in-service teachers are helped to overcome the current ritualisation of mathematics teaching in order to respond to any unanticipated problems and ideas coming directly from the pupils. Such a contention gains saliency from the James Report (1972:11) which proposed that in-service teacher training should start in schools, as opposed to a university because that is where the teaching and learning actions take place. The James Report is significant for Seychelles because it could take some years before primary teachers are offered formal training elsewhere in order to enhance their MKT.

1.2.1 Gaps in the Literature

This research carves its way into a focused area of MKT and seeks to address gaps in methodology, knowledge, and theory. It is essential for policy makers in Seychelles to know how primary teachers could contribute more effectively to the mathematical development of their pupils. Therefore, there is an urgency to move beyond the mere delivery of information by the teachers and towards the fruitful development of their MKT in order to improve the mathematical performance of their pupils. Various PD models such as lesson study, reflective practice, study groups, teachers' capacity to self-develop, can all play a part in teachers' ongoing knowledge development (Sellars, 2012).

A review of literature on MKT revealed that despite the variety and frequency of international research in primary mathematics education, inconsistencies and disagreements continue on how teachers' mathematical knowledge can be enhanced. Goos et al. (2008) note a lack of research on the MKT development of primary teachers over time. However, previous research and scholars (e.g. Herbert and Rainford, 2014; Mathew and Peechattu, 2017; Slade et al., 2019) have established that reflecting on practice has the potential to change the professional knowledge of teachers. Additionally, Delvin, Kift and Nelson (2012) argue that effective teaching is where there is Reflective Practice (RP). RP is a process that enables teachers to critically examine their practices by considering their pedagogical decisions, in order to continuously develop their knowledge as adult learners and to improve their practices (Tripp and Rich, 2012a; Walshe and Driver, 2019). Llinares and Krainer (2006) found reflection was one of the three main themes to emerge when discussing teacher change and development. It is argued by various researchers that one of the functions of RP is to develop teachers' knowledge (e.g. Schön 1983; Sellars, 2012). For example, Schön (1983) states that knowledge might be developed through reflection in and on action. Therefore, this is where RP could be of much help in this research.

One may argue that teachers' knowledge and their RP are two distant constructs. However, in this research they are seen as inseparable and inter-dependent, based on their parallel claims. Professional educators would claim that subject knowledge is not enough to guarantee effective teaching, whereas from an RP perspective, teaching experience is not enough to guarantee effective teaching. If both these arguments are merged, the outcome is something that is well worth investigating. RP is seen to be most appropriate for professional practice because it has the inherent characteristics to close the gap between theory and practice (see Section 3.4.2). Self-efficacy is also a component of this investigation because, based on Mezirow's (1991) transformative learning theory, which underpins this study (see Section 4.3.1), it is expected that change or growth in a teachers' MKT would be spearheaded by a change in their belief systems or self-efficacy. As will be discussed later (Section 3.4.13), self-efficacy is interpreted as a teacher's belief in their ability to positively change the learning outcomes of their pupils. RP and self-efficacy are inherently intertwined, so too are reflection and MKT. Bandura (1997) argues that self-efficacy is important in translating teachers' practical knowledge into practice. The inclusion of self-efficacy in this research is also motivated by the possible threats to teacher confidence due to continuous underachievement of their pupils; and self-efficacy of teachers permeates every aspect of their teaching. Various studies (e.g. Braun and Crumpler, 2004; Stallions, Murrill, and Earp, 2012) have made the positive interconnection between RP and teacher self-efficacy. Therefore, based on the above arguments, there is a clear link between MKT, RP and self-efficacy. That is, it is envisaged that the self-efficacy beliefs of teachers could be changed through RP so that their MKT could be enhanced. McDuffie (2004) found limited mathematical knowledge and lack of confidence in pre-service teachers' reflection. If primary teachers must develop their mathematical knowledge in order to become expert teachers, then it needs to be known how MKT and self-efficacy as important teaching constructs are developed.

Even though RP has been one of the most used theories for professional knowledge development (Kinsella, 2009), somehow, very few studies have explored how RP affects the MKT and self-efficacy beliefs of primary school teachers. For example, Leavy and Hourigan (2016) found important growth in two MKT sub-domains (KCS and KCT) of pre-service teachers when they were asked to reflect on their practices (see Section 3.4.12). Bargiband et al. (2016) found significant growth in the Pedagogical Content Knowledge (PCK) and Subject Matter knowledge (SMK) domains of MKT. This current research addressed the same two MKT sub-domains as Bargiband et al. (2016), but includes, and gives individual attention to, how RP impacts on five of the six types of MKT identified by Ball et al. (2008) (see Section 3.3.1 on MKT framework). Recently, Kuennen and Beam (2020) worked with prospective teachers and designed problem-based activities to develop their Specialised Content Knowledge (SCK), which is a sub-domain of MKT. However, Kuennen and Beam did not incorporate RP in their study. This research significantly differs from Bargiband et al. (2016), Leavy and Hourigan (2016), and Kuennen and Beam (2020). Firstly, it uses an intervention approach to address the educational phenomenon. Secondly, even if some researchers have conducted studies on MKT and RP (e.g. Suh and Parker, 2010; Bargiband et al., 2016; Leavy and Hourigan, 2016), none of them have addressed the effects of RP on five types of MKT through an intervention study. One of the main points of this research is that, despite the sparse literature on MKT and RP, and the recognition that teachers' MKT has a crucial effect on pupils' learning, rarely has the effect of primary teachers' RP on their MKT domains been explored. This research addresses this gap by investigating the effects of RP on the MKT and self-efficacy beliefs of primary teachers in Seychelles. The scarcity of such studies makes it a necessity to explore such phenomenon in the context of Seychelles, where pupils are scoring very low in primary school mathematics (see Tables 2.1 and 2.2). How do teachers reflect on their MKT in order to bring change to their classrooms? What we do know is that there has been little work done in this area. It is also true that the field of mathematics education in Seychelles lacks detailed understanding of how primary teachers develop their MKT. In fact, how primary teachers change their MKT sub-domains is something that has not been studied, neither in Seychelles nor overseas. Some of the impetus for this research comes from these facts; and this thesis proposes part of the solution by attempting to build on and extend the work of Bargiband et al. (2016), and Leavy and Hourigan (2016), in order to fill the gap in knowledge.

1.2.2 Focusing on Word Problem Solving Strategies

As stated in section 1.1, the annual national primary-six assessment reports in Seychelles continually indicate poor mathematics content in the performance of pupils along with lack of emphasis on problem solving (e.g. CCATS, 2014; 2015; 2016; 2017; 2018; 2019) which is an important component of primary mathematics. Moreover, pupils with high problem-solving skills have been found to perform well in their final examinations (e. g. Veerasamy et al., 2018). Internationally, researchers are also working to improve the teaching of word problem solving strategies (e.g. De Koning, Boonen, and van der Schoot, 2017; Mellone, Verschaffel, and Van Dooren, 2017; Mädamürk, Kikas, and Palu, 2016). The aforementioned local reports underscore the need for an effective intervention in mathematics teaching and learning; and moving away from the teacher-centred approach, which keep failing the pupils in various mathematical areas, to more research-informed, pupil-centred pedagogies. Also, with years of pupils' underachievement in mathematics (see Tables 2.1 and 2.2) primary mathematics teachers in Seychelles may lack the knowledge and confidence to teach mathematical word problem solving strategies. It is envisaged in the reports that word problems would develop the necessary mathematical skills, such as higher-order skills, and understanding in the pupils that will help them in other mathematics content areas. That is, the word problem as a form of problem solving involves tackling different other cognitive tasks that could help pupils to improve in other mathematics areas with which they keep struggling (Burkart and Bell, 2007; CCATS, 2014; 2018; 2019; 2020). Consequently, the researcher realised that if the teaching and learning of primary school mathematics in Seychelles is to be improved, it is not enough to develop the teachers in the teaching of basic mathematical computations and number operations. It is necessary to make an intervention in the area of the MKT and self-efficacy beliefs of word problem solving strategies, as it is the primary approach to teach problem solving (Depaepe, De Corte and Verschaffel, 2010); as well as a direction and 'fertile ground' for teaching and improving mathematics in primary schools (Burkart and Bell, 2007; Leong and Janjaruporn, 2015). Focusing on word problems allow teachers to have a repertoire of word problem solving strategies, and pupils to make the connection between school mathematics and its application in real life. Therefore, the researcher is convinced that mathematical knowledge of both primary pupils and teachers can be developed through problem solving in the form of word problems through RP.

1.3 Research Purpose and Objectives

The purpose of the research is twofold. Firstly, it seeks to investigate to what extent the five types of knowledge required to teach primary mathematics (Ball et al., 2008), and mathematics self-efficacy beliefs of primary teachers, change through an RP intervention. Secondly, it seeks to understand teachers' perceptions of the effects of RP on their MKT and self-efficacy beliefs in the teaching of arithmetic word problem solving strategies.

The specific objectives of this research are:

1. To elicit primary teachers' views and perceptions of their MKT domains, MKT self-efficacy, and MTSE development pertaining to the teaching of arithmetic word problem solving strategies.
2. To use a quasi-experimental design to establish the extent of RP intervention on the MKT domains, MKT self-efficacy, and MTSE of primary teachers.
3. To identify whether there are changes in the MKT sub-domains, MKT self-efficacy, and MTSE of primary teachers through RP.

4. To analyse the possible changes in primary teachers' mathematics practices after having experienced RP.
5. To provide details of this type of RP intervention for replication purposes.
6. To examine the effects of RP on primary teachers' MKT sub-domains, MKT self-efficacy, and MTSE beliefs for teaching arithmetic word problem solving strategies, in order to improve policy and practice.

The study was designed to answer one overarching research question with five subsidiary questions.

1.3.1 Overarching Research Question

To what extent does reflective practice change the MKT sub-domains, MKT self-efficacy beliefs, and MTSE beliefs of primary teachers pertaining to the teaching of arithmetic word problem solving strategies?

1.3.2 Subsidiary Research Questions

The following five key questions were used to answer the main research question:

RQ1. To what extent do the MKT sub-domains and MKT self-efficacy beliefs of primary teachers develop after engaging in RP?

RQ2. Is there a statistically significant difference between the MKT sub-domain scores of the intervention and control group after engaging in RP?

RQ3. To what extent does the MTSE level of primary teachers change after engaging in RP?

RQ4. Is there a statistically significant difference between the MKT self-efficacy beliefs of the intervention and control group after engaging in RP?

RQ5. Is there a statistically significant difference between the MTSE of the intervention and control group after engaging in RP?

The research hypotheses are presented in Section 6.1.2.

1.4 Overview of the Methodology

To answer the research questions, it was necessary to adopt a methodology that could triangulate multiple sources of connected data in order to provide a candid picture of the educational phenomenon. Therefore, a mixed-methods, multiple case study within an interpretive paradigm was used as the established methodological choice to examine the phenomenon (Bassey, 1999; Creswell et al., 2018). This study examined the effects of a reflective practice PD on primary teachers' MKT and self-efficacy beliefs. The study is located in the interpretive paradigm because it has the purpose of understanding the experiences and feelings of the teacher participants (Bryman, 2016; Cohen et al., 2018). Data sources include questionnaires, tests, transcribed interviews, and reflective journal entries. The questionnaires were used to gather teachers' self-perceived level of MKT and their mathematics self-efficacy beliefs. The tests also had the purpose of capturing and measuring the MKT sub-domains of the teachers. The semi-structured interviews were used to capture teachers' self-perceived changes in their MKT, self-efficacy, and practices. The reflective journals were used to document their experiences during the RP stage, and to capture their self-perceived change in their MKT, self-efficacy and practices. Both qualitative and quantitative analysis methods were used to analyse the data.

1.5 Significance of the Study

Although this intervention study was conducted in the context of Seychelles, it has a larger and very important scholarly significance as it anticipates adding to existing literature and shedding light on the stated theme of the research. Moreover, given that literature on the mathematical knowledge of teachers in SIDS is minimal to non-existent, it is hoped that this study will make a significant contribution to the otherwise scarce literature on MKT, with the ultimate aim that other SIDS will be able to relate with the Seychelles' case. The study, therefore, has both empirical, theoretical and methodological significance.

1.5.1 Empirical, Theoretical and Methodological Significance

Firstly, the research took place in Seychelles with a convenient sample of teachers who were willing to participate. The fact that the study itself raised some curiosity about reflective practice and mathematical knowledge development bears significance. The study is also significant because it uses experimental evidence to shed light on an area of mathematics education that is under researched in Seychelles. The empirical contribution is such that the study tested the theoretical linkage and effects between RP, MKT and MKT efficacies, which has not previously been carried out. To the researcher's knowledge, no empirical research has been conducted in Seychelles in relation to the mathematical knowledge of primary teachers, and how it can be developed. There is also little formal scholarly study on how RP enhances the MKT and efficacy of teachers. One Seychellois researcher (Valentin, 2013) conducted a doctoral study on Mathematics Lesson Structure to improve the teaching of mathematics in primary schools. However, Valentin's research did not address teachers' mathematical knowledge. Hence, the view that the MKT of primary teachers in Seychelles needs major, in-depth research in order to improve practices. On the other hand, a number of studies have discussed ways to improve teachers' general mathematical knowledge (e.g. Silver et al., 2007; Koellner et al., 2007; Bell et al., 2010; Ribeiro and Powell, 2019) in order to raise pupils' attainment. Further significance of this research is that, while previous studies have linked teachers' knowledge and pupil achievement (e.g. Hill, Rowan, and Ball, 2005; Baumert et al., 2010), few empirical studies have attempted to address how primary teachers' MKT sub-domains and their self-efficacies can be enhanced using a PD model. Therefore, this research has empirical significance because it is the first major study conducted by a local researcher where experimental data are used as evidence to address the mathematical knowledge of primary teachers in Seychelles. The methodological significance is such that this study integrates a quasi-experiment within an inductive design (e.g. Green et al., 2015) to better explore the phenomenon.

1.6 Organisation of the Thesis

The thesis is presented in nine chapters. Chapter 1 sets the scene of the study through a detailed presentation of the research problems and the gaps in the literature. The research objectives and questions are also presented. These are followed by an overview of the methodology, and the significance of the study. The chapter concludes with the organisation of the thesis followed by the chapter summary.

Chapter 2 examines the historical and political context of the research, including: the context of the education system; the development of schools and education in Seychelles; primary education in Seychelles; teacher education, and trends of underachievement in mathematics education in Seychelles.

Chapter 3 provides a critical review of the literature pertinent to the enhancing of MKT and self-efficacy through RP. It is within this chapter that the seminal works of Shulman (1986), the MKT framework of Ball et al. (2008), and Gibbs' (1988) reflective cycle are considered, presented and discussed. The chapter also defines the various theories, outlines important studies, and identifies the gaps in the literature.

Chapter 4 identifies and proposes the conceptual and theoretical frameworks for the study. Firstly, the conceptual framework (e.g. Desimone, 2009) is presented and examined. Then, the theories framing the studies (e.g. social-constructivism and Mezirow's1991 TLT) are presented and examined.

Chapter 5 provides a detailed report on the methodological stance of this research. The epistemological, ontological, and methodological approaches underpinning this study are outlined. Then the chapter outlines the research methods, validation and trustworthiness, data collection procedures, data analysis procedures and ethical considerations.

Chapter 6 presents the quantitative results and the analysis of the data in relation to the research hypotheses. It provides details of the quantitative analysis procedures and explains how SPSS software is used to analyse different aspects of the data in order to answer the research questions.

Chapter 7 presents the qualitative findings and the analysis of the data in relation to the research questions. It is within this chapter that the case studies from the seventeen participants are developed, and the themes are identified.

Chapter 8 triangulates the data; then, merges and discusses the findings. Whenever it is necessary, the chapter refers back to the literature to show that the findings correspond with the literature. The chapter also proposes a framework for MKT development and a typology of teachers' self-efficacy growth.

Chapter 9 is the final chapter and concludes the thesis. This chapter summarises the key findings of the study and discusses the contributions to knowledge made. The chapter also discusses the limitations of this study, recommendations for policy and practice, recommendations for further research, and reflects on the professional development of the researcher.

1.7 Chapter Summary

In summary, evidence from literature suggests that there have been significant global calls from both developing and developed countries to improve the mathematics experiences and achievements of primary school pupils. A great number of primary-school pupils in Seychelles are under-achieving in mathematics, and their performance is being linked to poor MKT of teachers. A major issue and its proposed solution have both emerged from this chapter. The issue is that if mathematics performance of pupils is to be improved, then the MKT and self-efficacy beliefs of their teachers would have to be enhanced. Consequently, the proposed solution is that RP could be used to address weaknesses in teachers' MKT. On the other hand, whilst there may be agreement about the association between teachers' MKT and RP, it is based on inadequate local empirical evidence. There is little and insufficient evidence to support the thesis that RP intervention could lead to improved MKT in teachers. In that sense, the purpose of this research is to examine to what extent RP intervention may enhance the MKT and self-efficacy beliefs of teachers. This chapter has provided the background and rationale for this study. This is now linked to the context of the study, in the next chapter.

Chapter 2: The Historical and Political Context of the Study

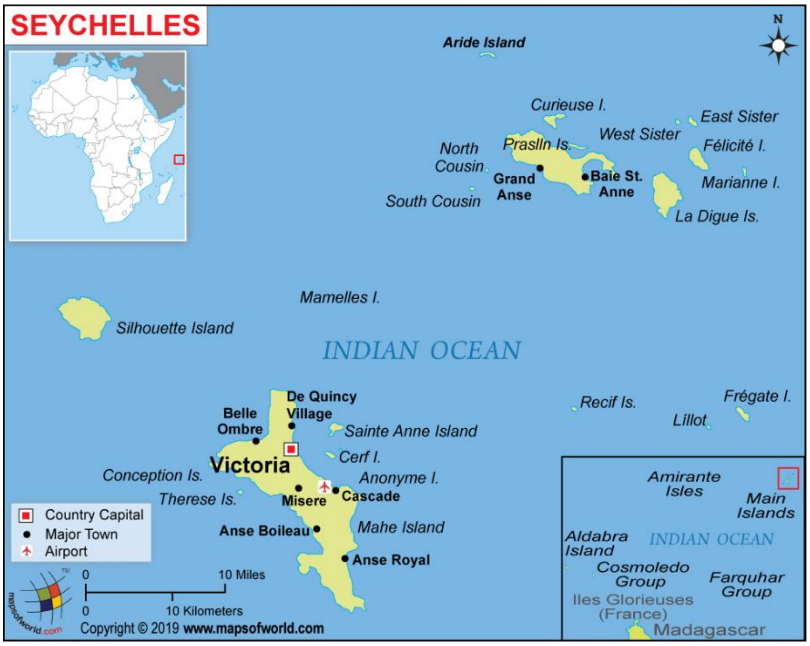
2.1 Introduction

The previous chapter made theoretical arguments and described the educational phenomenon of the study. This chapter presents the historical and political context of the study. It also places the study in its physical and temporal context in order to understand the present status of Seychelles' education system and the challenges it faces. The chapter is divided into seven main sections. Section 2.2 provides an overview of the education system. This is followed, in Section 2.3, by a brief history of the development of schools and education in Seychelles. Section 2.4 discusses primary education in Seychelles and the major issues attached to it. Section 2.5 provides an overview and assessment of primary teacher education. The penultimate section details the underachievement in primary mathematics in Seychelles. Section 2.7 summarises the chapter.

2.2 The Context of the Education System

The findings of this research are best understood in the light of its contextual factors. Therefore, a presentation of the context strengthens the external validity of the study (Cohen et al., 2018). The Republic of Seychelles is a Small Island Developing State (SIDS), and a Creole-speaking nation located in the western Indian Ocean, four degrees south of the Equator (see Figure 2.1). This nation, which gained independence from the UK in 1976, is an archipelago consisting of 115 coral and granite islands. It has four inhabited islands. The two largest populated islands are Mahé and Praslin, and this is where the schools used in this research are located.

Figure 2.1: Map and location of Seychelles islands



(Source:https://www.mapsofworld.com/seychelles/)

The population of Seychelles was estimated to be 97,625 as of 30th June 2019 and has a labour force of over 52,453 as of 28th June 2019, with a literacy rate of 96% (National Bureau of Statistics, 2019). The majority of the workforce is trained by the various tertiary institutions such as the technical schools and the teacher training institute. This places education as an important factor for the economic development of the country and the social progress of the people, thus making policy interventions in education amenable to economic evaluation (Machin and Vignoles, 2006). Seychelles is highly dependent on importation, with 70% of food being imported. Due to the limitation of industries and lack of diversification of the economy, Seychelles has to rely on two main economic industries, which are tourism and fisheries (Martin, 2010).

2.3 Development of Schools and Education in Seychelles

Institutionalised and compulsory education was established in 1770. Seychelles was originally colonised by the French and later became a British colony in 1814, remaining so for over 150 years. English language remains one of its official languages and is the medium of teaching in schools, followed by French and Creole. The history of education in Seychelles started in 1829 when Seychelles was still a British colony (Seychelles Nation: 5th April 2013). A Major William Colebrooke (1787-1870), in his 1829 commission report on the condition of the slaves, also spoke of the necessity to have a church and a school on the island. However, the first school was built by James Moses Collie (1805-1872) in 1830 for the children of the British inhabitants. In 1839, upon the request of Charles Augustus Mylius, two colonial schools were built for the children of slaves with the aim of sustaining colonial administration (Jackson, 2015). Due to lack of resources and interest, the schools did not make much educative progress until 1854 when the Catholic missions started building churches and chapels with schools within them. Historically, education was initially driven by colonial and religious motives rather than by a desire for academic excellence. There was a near monopoly of the Catholic Church in all matters of education and the Catholic missions dominated the education system of Seychelles for many years. The current education system of Seychelles was handed down from the colonial British system and later modified. By the 1880s and late 1890s, the primary school curriculum included dictation, arithmetic, reading, grammar, music and needlework. In 1944 the government was given full control of the education system, which resulted in a ten-year development plan where English was chosen as the medium of instruction in the schools. The 1950s saw major expansion and development of schools, culminating in a total of thirty-three schools attended by 6094 pupils. Two prominent schools were the Seychelles College for Boys and the Regina Mundi convent for girls. The researcher had the privilege to attend the Seychelles College between 1979 and 1981. Secondary schools grew in number after 1966, and shortly after the independence from the UK more changes were made to include a zoning system and the compulsory use of Creole (e.g. mother tongue policy) as the medium of instruction in primary schools. The language reform was due to claims that the use of English language for classroom teaching resulted in poor academic performance (e.g. Komba, and Bosco, 2015; Early and Norton, 2015). However, such compulsory use of Creole to teach mathematics in the early primary stage led to problems involving the highly specialised mathematical terminologies; and later, when the teachers had to switch the medium of instruction over to English at the upper primary level, this caused an extra hurdle in the teaching and learning of mathematics at primary level, especially relating to mathematical word problem solving strategies, which is one of the subjects of this research. So, during the early period of colonisation, the school setting and curriculum were devised by the British in conjunction with the Catholic Church of that time. This is not dissimilar to the UK where the churches (mostly Anglian and Catholic) provided education before the state really became involved in 1870. Before the year 1870, the teaching of mathematics was highly teacher-centred; and such pedagogy was brought, mostly by Western and colonial powers, to Africa (including Seychelles), the Middle East, and Asia during the earliest school practices (Jackson, 2015). However, by the year 1890, the education system had evolved to be a more progressive one, where teachers were encouraged to take a more modern approach to teaching and learning. Pupil-centred pedagogy was considered to be the appropriate pedagogy for increasing pupils' performance. However, the mainstream educational practice in Seychelles continued to be, and still largely is, traditional and teacher-centred, as explained by Khalaf and Zin (2018).

Currently, Seychelles has a centralised education system comprising of thirty-four public schools and three private schools. These comprise of creche or pre-primary, primary, secondary, and tertiary education. English is the medium of instruction from primary three (P3) level or grade three, where pupils are usually 8 to 9 years old. There are a number of post-secondary institutions from which pupils can select in order to continue their studies. These include both vocational and academic institutions as well as a university which opened in 2009. In the late 1980s, the education policies of Seychelles started to evolve and took different forms. A marked change in education policy took place in 1984. The policies were guided by Education For All (EFA), Education For Life (EFL) and Education For Personal and National Development (EFPND) (MOE, 1984).

Since the establishment of a free and comprehensive school system in 1981, the inherent challenges have been to provide effective education for the population. The various initiatives to reform the educational system have presented many challenges and have had no clear impact. Despite some recognised achievements some issues remain:

> *In spite of the many initiatives to improve education quality so far, evidence presented under the other goals suggests that*

> *three pupil groups are not being reached effectively: pupils experiencing learning difficulties, those with behaviour problems and pupils with disabilities*.
>
> (MOE, 2015:60)

Such concern is also shared by World Bank Group (2008) and Jones et al. (2014) who affirm that in spite of investment, eastern African schools have not improved in learning levels. In light of the above initiatives and developments, there was a clear view of the importance of education. The change in policies was to ensure that the education systems continued to improve in order to better empower the learners. Thus, while investment in education by the Ministry of Education (MOE) was necessary, its positive outcome is still being seen as a challenge.

2.4 Primary Education in Seychelles

If a country has to improve the educational output of its citizens, it has to start by improving its education system at all levels, starting with its primary education (Hourigan and Leavy, 2017). The Plowden Report points out that "primary education equips children to benefit from later schooling and further higher education" (CACE, 1967, para. 1172). The report is still valid for Seychelles' primary education, with a similar aim of improving the nation through education and seeing the child as the unit of change. Primary education in Seychelles is compulsory, and free for pupils, in government or public schools. The pupils progress automatically from one year-level to the next. There are twenty-five primary public schools and three private schools spread across the three main islands. Pupils complete two years of pre-primary (crèche) (aged between 4 and 6) and six years of primary education from primary one (P1) to primary six (P6) (Seychelles Framework for Early Childhood Care and Education, 2011). The latest recorded pre-primary enrolment figure is 100% compared to 2% in Mali (UNESCO, 2015). The primary education in the public schools is guided by a prescribed national curriculum developed by the MOE and comprises a wide range of subjects, including mathematics, sciences, physical education, and social science, amongst others. Creole and English are the two introductory primary languages of instruction, with French being introduced at a later stage. However, English is used as a second language in the primary education system as well as in the country at large. School performance data for primary school pupils are taken and measured at key stages through the Seychelles National Annual Assessment (SNAS) in year two (age 7), year four (age 9) and year six (age 10 or 11), which is the last primary year. These examinations are administered at the end of each school year, and they play a similar role to the league tables in England which is, partly, to monitor the curriculum, gather school performance data, and for the individual assessment of pupils so that achievement targets can be set. After the completion of their primary education, pupils can continue for five years (S1-S5) of secondary education. There is quite a substantial performance difference among primary schools, a challenge common to many SIDS.

Most of the current primary school teachers in Seychelles are females in the age range of 20 to 55. Historically, primary teaching is viewed as a feminised profession. Such gender imbalance is not uncommon globally, and for years primary school teaching has been dominated by females (Amaele and Okenwa, 2018). For example, more than 80% of primary teachers in the USA, UK, and Ireland are women; and many countries have raised concerns about such gender imbalance in primary teaching (Davis and Hay, 2018). Both Europe and Africa are experiencing feminisation of primary teaching (Osaat and Okenwa, 2018).

Some of the major priority areas of the MOE include the guarantee of quality education in primary schools, improvement in the quality of primary teachers, creation of responsible and empowered pupils, in order to pursue economic growth (MOE, 2014). Ahmad et al. (2013:326) point out that the "role of primary education is threefold in the economic development of a country due to its highest rate of return". Therefore, the government of Seychelles, as well as other governments, should understand that a firm and strong primary education system leads to a more skilled workforce. Brown et al. (2008) explain that one way to outsmart economic rivals and gain competitive advantage is through investment in education. Therefore, expenditure on primary education in the form of developing teacher knowledge should be part of the long-term economic development of the country. Seychelles should not retreat in its responsibility of investing in primary education for economic growth, as a smart economic development policy. Therefore, such economic arguments make the case for conducting research into primary education more compelling.

2.5 Primary Teacher Education and Quality

Seychelles has only one teacher training institution; training is undertaken by the Seychelles Institute of Teacher Education (SITE) which is mandated to plan and deliver teacher-training programmes up to diploma level for both primary and secondary teachers. Student teachers enrol with the institution either as pre-service or in-service teachers. The fundamental primary education training programme for pre-service teachers consists of a four-year, full-time course leading to a certificate in primary education. The pre-service teacher training programme enables teachers to spend a considerable amount of time on practical work. The teachers are trained to teach most of the core subjects in the primary curriculum, including mathematics, during the first two years of their teacher-training programme. Their mathematics training includes mathematics content knowledge and mathematics pedagogy. Various studies have argued that teacher education has failed to influence classroom practices (e.g. Korthagen, 2010; Mupa and Chinooneka, 2015). Therefore, failing to develop teachers' MKT and self-efficacy during teacher training could later impact negatively on their practices and pupils' learning outcomes. Other factors can also affect the quality of primary education, and this could include teacher-training quality and teacher attrition. Teacher attrition is a problem and is inextricably linked to the mathematical performance of pupils in Seychelles. However, raising the salary of teachers, both in Seychelles and in other countries, has not been successful in reducing teacher attrition (e.g. Colson and Satterfield, 2018). In the UK, one third of teachers leave teaching during the first five years of service. Ronfeldt et al. (2013) explain that high attrition rates have a negative impact on the pupils' learning outcomes due to variations in instruction. Leste et al. (2005) comment on the fact that the MOE is aware of the acute shortage of well-qualified teachers in primary schools in Seychelles, however, fourteen years later the situation has not improved, but rather deteriorated. Several schools are running their subject departments with Teaching Assistants (TAs) who need to undergo proper teacher training, and this is a significant problem for some schools. Despite being untrained, the TAs are currently playing a major role in the provision of mathematics education in Seychelles.

The high attrition rate of teachers has also compromised the rigour of initial teacher-training entry requirements of pre-service teachers in Seychelles. Also, there is no formal evaluation system for the teachers whereby they are evaluated according to the level of their pupils' performance. In 2011, as part of the reform actions, a 'Performance Appraisal System' for teachers was introduced to encourage better teacher performance. This was used as a guide for the remuneration of teachers and to develop a performance-driven culture in education. However, Forrester (2011) explains that the introduction of performance management in education has not been without debate. While this might strengthen scrutiny and monitoring of teachers' work, it does increase bureaucracy and so can be seen as an additional burden (Forrester, 2011). In the absence of a formal evaluation system and research, it is difficult to assess the efficacy of teachers once they graduate from the teacher training institution, and, in the case of Seychelles, whether SITE fits its purpose. The assessing of teacher education programmes is crucial because it can help to identify weak programmes which need to be improved or replaced (Darling-Hammond, 2006). The fact that Seychelles does not participate in any international assessments, such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), makes it difficult to obtain a comprehensive picture of a teacher's performance in terms of the outcomes of their pupils. However, Seychelles is one of the southern and eastern African low-income groups of countries assessed by a different regional test known as the Southern and Eastern Africa Consortium for Measuring Education Quality (SACMEQ). SACMEQ is an established body, sponsored by UNESCO, and monitors education quality in several countries. Among other tasks, SACMEQ compares the reading and mathematics tests of grade-six pupils and teacher performance in education. The most recent study was conducted in 2013 (SACMEQ IV) with the participation of fourteen East African countries including Seychelles. In the 2013 regional comparative study, Seychelles was ranked third out of the fourteen countries for mathematics and reading scores, behind Mauritius and Kenya (Bandi, 2016; Sandefur, 2018). The study also compared achievements of pupils over time, with SACMEQ II (2000-2004), SACMEQ III (2007-2011) and Bandi (2016) [on SACMEQ IV 2013]. In terms of SIDS, level of development and pupil performance in Seychelles is comparable to that of pupils in Mauritius. Some international studies have identified a correlation between teacher quality and pupil achievement (e.g. Ma, 1999; Harnett, 2012; Hanushek, 2016), while others (e.g. Gersten et al., 2013) show a positive correlation between teacher development and their practice; but not with pupils' outcomes. Most recently, Sirait (2016) also found a positive relationship between teachers' evaluation scores and pupils' achievement, thus providing saliency to this research.

2.6 Underachievement in Primary Mathematics in Seychelles

> *The Ministry of Education has invested heavily in teacher training but returns in terms of aggregate scores for P6 National Examinations over the last three years have not reached expected standards.*
>
> (MOE, 2014:45)

Primary mathematics education in Seychelles has a lot of teaching and learning issues. Pupils are underachieving, and a great number of pupils find the subject difficult (MOE, 2015; Waters, 2015). The various national initiatives, changes and strategies made by the MOE over the past two decades, to improve performance in primary and secondary mathematics, have not, however, translated into any significant success.

> *Evidence of underperformance by pupils at the end of primary and secondary schooling persists, in spite of a number of reform initiatives over the past two decades that have attempted to enhance the capacities of school leaders and teachers and improve learning and teaching resources.*
>
> (MOE, 2015:60)

This implies that many of the basic mathematical concepts prescribed in the mathematics curriculum have not been properly understood by a great number of pupils. Similarly, researchers in mathematics education in other countries (e.g. Jacob and McGovern, 2015) have found that the teaching of mathematics remains unchanged in spite of the various initiatives and efforts by reformers. Previous international studies, such as

Raymond (1997), have argued that teachers' beliefs about mathematics are more resistant to change than their beliefs about teaching. However, those studies are being challenged with new findings (e.g. Leavy and Hourigan, 2018b) which suggest that it is possible to make improvement in teachers' beliefs and attitudes through educational programmes, as evidenced here in Section 7.3.5. In 2003, in response to such concerns, and following the longstanding claims about pupils' weak performance, the MOE in Seychelles came up with initiatives and reforms to address the problem of underachievement in primary mathematics. Some of the initiatives took the form of workshops and further, ad-hoc, training for teachers. One of the initiatives gave birth to a project coined 'Improving Pupils' Achievement in Mathematics (IPAM)', with the ultimate aim of improving the quality of primary mathematics education. The IPAM project introduced a lesson-plan format, Mathematics Lesson Structure (MLS) (Valentin, 2013). In 2018, MLS was replaced by another Mathematics Lesson Structure coined Lesson Evaluation Structure (LES). However, in 2020, pupils in Seychelles are still underperforming in primary mathematics.

2.6.1 Historical and Current Context: Significance of the Annual Examination Reports

The need to improve the economic situation of Seychelles has generated substantial political anxiety and places an important demand to report on the academic success of pupils. The significance of the annual P6 examination reports is that they provide the MOE officials, parents, and teachers with concrete information and reflections on the performance of pupils in the various subjects, as well as their general achievement during the primary school cycles. Furthermore, the reports provide the government with information on the improvement of learning outcomes in schools, which is somehow linked to future prosperity of the country (Fenwick and Cooper, 2013). Specific to mathematics, the reports aim to explain the performance of the pupils which is somehow inextricably linked to the MKT of the teachers and teacher effectiveness (CCATS, 2014). The reports have developed over time to provide transparent and quite detailed contextual factors with regards to the performance of the pupils and their learning issues. The reports help to provide a comprehensive view of the MKT the teachers would need to possess (Ball et al., 2008). They have also opened a line of communication amongst policy makers, educationalists, and teachers that can bring about change and improve the mathematics education experience of pupils. Also, considerable attempts over the years have been made to curb some of the contextual factors that contribute to conflicting interpretation of results. Increasingly, the P6 annual reports provide more meaning and context alongside the statistics (e.g. CCATS, 2018; 2019; 2020). The historical context of mathematics education enables us to understand what influenced the mathematical pedagogy of the teacher, as well as to help us analyse and interpret the current results of the students, and the performance of the teachers in their classrooms. A history of mathematics failure in the primary schools has greatly affected the current views of Seychellois at large towards mathematics and features greatly in the current public discourse on education. Historically, the mathematics education delivery in Seychelles has been diversely affected by early schooling practices, social, cultural and economic contexts, school environments, settings and resources, to include the adoption of curriculums isolated from their context. This has made it hard to explain the seemingly inconsistent results of the pupils. Somehow, the historical context of mathematics teaching has not changed much from the current context. Teachers' pedagogical orientations, which are strongly linked to their practices, have not changed much over the years despite change in education policy. There are still limitations in teachers' mathematical knowledge, lack of resources, and the teaching and learning environment (context) remaining almost the same. These issues have restricted teachers and prevented them from improving their practices and, in some cases, implementing their own beliefs in practice. But despite the continued challenges, in their own way the teachers are still finding ways to improve the mathematical experiences of the pupils.

2.6.2 Grade 6 Mathematics Examination Trends

Internationally, various studies have expressed concern regarding underachievement of pupils in mathematics (e.g. Mundia and Metussin, 2019; Julaihi, Li, and Eng, 2020). For example, results from PISA 2015 for the UK show that 22% of pupils are low achievers in mathematics. Furthermore, 23% of pupils across the OECD countries do not reach the baseline level in their mathematics performance (OECD, 2016). Even if direct comparison cannot be made with those international large-scale assessments in education (e.g. PISA and TIMSS), lessons can be learnt from them.

The performance of pupils in primary mathematics fluctuates over the years and fails to make considerable improvement and is without statistical normality. For example, the 2017 national assessment of educational progress recorded a low mean of 39 % on the annual standardised P6 examination (CCATS, 2019; see Tables 2.1 and 2.2). For the 2014 IGCSE examination results, only 27% of the pupils obtained a grade C or above in mathematics (Today in Seychelles, 25th January 2016).

Table 2.1: 1998-2002 P6 National examinations mean by subjects
Source: Mathematics working group 2005

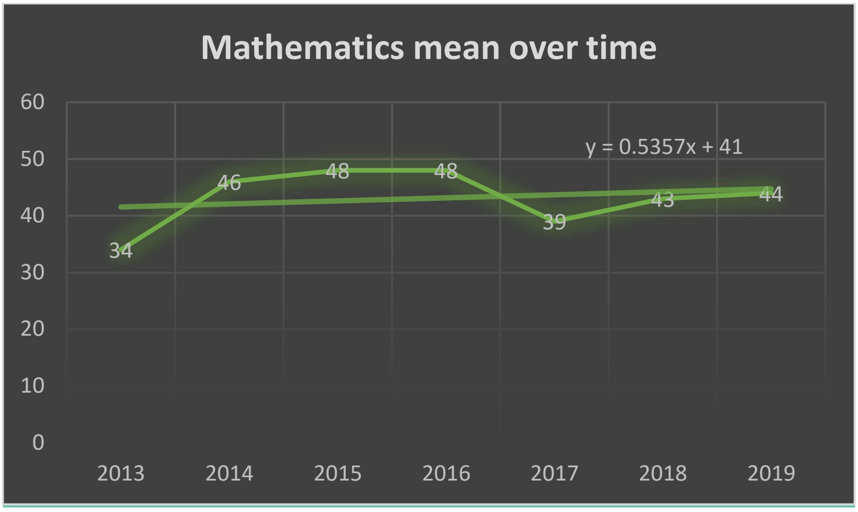
Subject	Mean 1998	Mean 1999	Mean 2000	Mean 2001	Mean 2002
Mathematics	43%	40.2%	41%	36.5%	29.9%
English	56.6%	51.9%	50%	49.6	41.7%
French	62%	50.6%	58%	46.7%	53.2%
Creole	55.3%	54%	56%	49.9%	51.5%
Science	53.2%	50.3%	49%	44.5%	53.3%
Social studies	54.5%	49.7%	52%	55.8%	46.1%

Table 2.2: 2013-2019 P6 National examinations mean by subjects
Source: P6 National examinations 2018 and 2019 reports

Subject	Mean 2013	Mean 2014	Mean 2015	Mean 2016	Mean 2017	Mean 2018	Mean 2019
Mathematics	34%	46%	48%	48%	39%	43%	44%
English	40%	42%	38%	51%	50%	51%	48%
French	53%	45%	50%	50%	56%	53%	47%
Creole	58%	54%	47%	47%	56%	58%	52%
Science	42%	51%	43%	43%	42%	45%	45%
Social studies	51%	49%	47%	47%	48%	42%	46%

Longitudinally, Tables 2.1 and 2.2 show the low mathematics performance of the grade 6 pupils for the past twelve years in relation to other core subjects. In Figure 2.2, the data tells a story of poor maths performance in 2013, significant improvements in 2014, 2015 and 2016, a sharp drop in 2017. Particularly notable, in 2018 and 2019, there were improvements in the mean scores.

Figure 2.2: National mathematics means for grade 6 for 2013-2019 and trendline



The fact is, you cannot read too much into one year's mean and so Figure 2.2 has been used to show the data trend. Figure 2.2 shows the national mathematics mean for grade 6 for 2013-2019 and its trendline of linear equation (y=0.5357x+41). The trendline shows a slow upwards direction of the mathematics mean. For three years (2014-2016), there was a stagnation in the mean followed by a sharp drop in 2017. Despite the slight upward trend, since 1998 until now, the annual means have been below 50%. Taken together, when interpreting Figure 2.2, it is clear that there is no consistent long-term trend in the data, and this could be due to possible statistical outliers, thus distorting and leading to a biased calculation of the mean (Strutz, 2010). Therefore, in this context, the current policy of using the mean to report the national performance of schools in Seychelles could be an invalid measure of central tendency. Furthermore, the low averages suggest that a lot of pupils are entering secondary schools without a good foundation in mathematics, and ultimately enter the labour market with poor mathematics skills (Machin and Vignoles, 2006; Vignoles, 2016), thus endangering their likely labour-market success. It seems that, in the context of Seychelles, the teachers are held accountable for the low performance of the pupils. A great number of pupils are stuck at the bottom end of the statistics normal curve. Such a result gives cause for concern and calls for scholarly attention and reform in primary mathematics education in Seychelles.

2.7 Chapter Summary

This chapter has outlined and illuminated the historical and political context of the study by presenting the development of education in Seychelles, making special reference to primary teacher education and teacher training. In addition, it also made some attempt to explain the underachievement in primary mathematics. These contexts and indicators were examined in order to provide a baseline and backdrop for later analysis. The history of schools and education after independence shows how much has been achieved in that short period of time. Nevertheless, the slow progress also points to important educational issues that need to be addressed. Two important observations are made from this chapter, leading to two main emerging issues. Firstly, the major changes and development in education occurred after independence. These consisted of major reforms, leading to significant progress towards education for all. Despite these improvements, the primary education institutions have experienced low performance and underachievement of pupils in primary mathematics, where a great number of pupils are performing at the low end of the distribution. Secondly, the persistent and severe shortage of teachers has filtered down to primary schools, resulting in the schools having to use TAs to take up full-time teaching responsibilities even though they do not have sufficient MKT. The next chapter reviews the literature for the study.

Chapter 3: Literature Review

3.1 Introduction

The previous chapter set the scene of the research by presenting the historical and political context. This chapter examines related literature and research findings that support the development of teachers' Mathematical Knowledge for Teaching (MKT), and self-efficacy beliefs through Reflective Practice (RP), in order to produce quality teaching and improve pupils' learning outcomes. It also critically reviews relevant literature that informs the design of the study. The literature review for this research is conducted for three main purposes (Maxwell, 2006). Firstly, it establishes a scholarly significance of the research problem by presenting previous research in the area. Secondly, it situates this investigation within previous studies in order to justify the main research question and sub-questions, so that the gaps in the literature can be addressed. Thirdly, it describes a conceptual and theoretical framework, and places them in the context of the study (Savin-Baden and Major, 2013; Cohen et al., 2018). From an educational perspective, the literature shows a connection between teachers' RP with their MKT, and self-efficacy. This research investigates more precisely to what extent RP affects the MKT and self-efficacy of primary school teachers. The review is multifaceted; it comprises an in-depth review of the literature pertinent to RP and teachers' mathematical knowledge development, and self-efficacy. The impetus and contention put forward for conducting this study is that primary school pupils are underachieving in mathematics in Seychelles. As discussed in Chapter 1, both local evidence and a review of literature, both nationally and internationally (e.g. Tatto et al., 2012; MOE, 2014a) reveal that primary mathematics teachers lack MKT. Consequently, there have been long-standing calls to improve teacher quality in the primary schools of Seychelles in order to improve the teaching of mathematics and, subsequently, the mathematics outcomes of pupils. One possible factor influencing the poor performance of pupils could be the MKT of the teachers (Hourigan and O'Donoghue, 2015; CCATS, 2017). This chapter attempts to capture the current insights and views about RP, teachers' MKT and self-efficacy beliefs, and motivate a discourse on the development of their mathematical knowledge and self-efficacy.

3.1.1 Chapter Overview

This literature review is grounded on the premise that the way mathematics teachers approach their classroom teaching, so that pupils grasp the core mathematical ideas, depends partly on their mathematical efficacy and knowledge for teaching (Ball and Bass, 2000; Hill, Rowan, and Bass, 2005). The chapter is organised into seven sections. The first section introduces the review and its methodology. Thereafter, Section 3.2 presents the development of MKT research. It is followed by Section 3.3 with a presentation of the MKT framework, and review of studies. Section 3.4 examines literature on RP as professional development and self-efficacy beliefs. Then, Section 3.5 presents a discussion on mathematical word problem solving. Section 3.6 addresses the gap in literature, and finally Section 3.7 summarises the chapter.

3.1.2 Methodology for the Review

The search for the literature was conducted through the Staffordshire University Library electronic databases and several online databases (e.g. ERIC, Google Scholar and JSTOR) using different criteria. The researcher also searched through reference lists of journal articles. The review of the literature was primarily conducted using journal articles, books and reports written predominantly between the years 2015 to 2020, except for seminal studies which were exempted from this timeframe. The rationale for this period is that the issues covered in this research are constantly evolving, as have various elements which surround them (Savin-Baden and Major, 2013). The search terms used include teachers' practical knowledge, professional development, mathematical knowledge for teaching, and self-efficacy beliefs. In addition, seminal works on teachers' knowledge for teaching and RP were consulted, including Shulman (1986, 1987), Ball et al. (2008) and Schön (1983).

3.2 The Development of MKT Research

Using the words of Cohen (2008:358), one of the roles of teachers is to "launch knowledge toward learners". The Concise Oxford English Dictionary defines knowledge as:

Information and skills acquired through experience or education.

In this study, the research partly adopts Oxford's definition and defines knowledge as the understanding or information gained through experience or the study of a subject, and most probably resides in a person's mind. From such a definition, it is clear then that knowledge is something that one either possesses or does not possess. Therefore, in this thesis, teachers' knowledge entails the information and understanding teachers have about their subjects, and how to act on it. Knowledge has multidimensional characteristics such as tacit, explicit, subjective, and objective, among others. Tacit is hidden knowledge, action-oriented, not openly expressed, and remains in the head of the individual. The tacit-knowledge approach is important when considering the professional development of teachers because if knowledge is internal to them, then new knowledge can be created when teachers come together if they intend to share their personal knowledge. In contrast to the obscure nature and characteristics of tacit knowledge, explicit knowledge is the assumption that knowledge can be articulated by the individual and very often gained through formal education. Alavi and Leidner (2002) explain that the two are mutually dependent and reinforce the qualities of each other. Tacit knowledge forms the background for the development of explicit knowledge. For example, a teacher's mentor would most often use tacit knowledge to help guide a novice teacher. Therefore, this study assumes that the explicit knowledge created and gained by teachers can be articulated. This intervention focuses on developing both types of knowledge.

3.2.1 Construction of Knowledge

Researchers have designed various theoretical frameworks to help us understand the type of knowledge teachers should possess to teach effectively. One such framework is conceptualised by Skemp (1976, 1987). Skemp's cognitive framework makes the distinction between conceptual knowledge and procedural knowledge. Skemp (1976) uses the terms instrumental and relational understanding to explain the type of knowledge teachers should have to teach mathematics effectively. Instrumental understanding (rote learning) is just the rote memorisation of mathematical algorithms and processes, compared to relational understanding which is deep conceptual understanding of what is being learnt (Holmes, 2012; Tall, 2013). Skemp implies that mathematics teachers should have a deep conceptual understanding of the subject matter. Conceptual knowledge and procedural knowledge are divisions of Shulman's (1986) content Knowledge (CK) constructs. Ball (1991) defines the knowledge of mathematics teachers as being both conceptual and procedural, and knowledge about mathematics as the understanding of the nature of the subject matter. Procedural knowledge is rich in rules and strategies, and it is about the execution of action sequences through specific algorithms to solve mathematical problems (Hiebert et al., 2005; Rittle-Johnson and Schneider, 2015). Conceptual knowledge involves the understanding of mathematical concepts and relationships; a connected web of knowledge (Hiebert et al., 2005). A growing body of research stresses the importance of conceptual understanding in the teaching of mathematics (e.g. Holmes, 2012). Without proper understanding of the concepts, pupils will not be able to make real-life applications of it. NCTM (2014) emphasises that schools should be implementing conceptual rather than procedural knowledge despite the general agreement that both types of knowledge are important (Tall, 2013; Rittle-Johnson and Schneider, 2015). In order to teach holistically, primary teachers should be able to promote both the conceptual and procedural aspects of mathematics learning.

3.2.2 Historical Perspectives of Teacher Knowledge

> *There is a widespread public perception that good teachers simply need to know a lot. But teaching is not a knowledge base, it is an action, and teacher knowledge is only useful to the extent that it interacts productively with all of the different variables in teaching*
>
> (Boaler, 2003:12)

Boaler's perspective on teacher knowledge gives saliency to this research by arguing that teaching is a complex activity involving multiple knowledge types, among them are the thoughts and actions of teachers. Knowledgeable teachers are crucial for the meaningful and effective development of pupils' mathematical knowledge, ways of thinking and learning mathematics (Shulman, 1987; Hattie, 2012; Chapman, 2017). However, the reader is reminded that teachers' knowledge is just one of many other effective principles for effective mathematics pedagogy.

When reviewing historical literature on teachers' knowledge for effective and quality teaching, there have been three main areas of inquiry or models of research. These are process-product, educational productive functions, and teacher knowledge. In the 1970s, the process-product model of teaching was used to evaluate teaching effectiveness. This was based on the premise that certain behaviour or actions by the teacher (process) would affect pupils' performance or attitudes towards their learning (product) (Verloop, Van Driel and Meijer, 2001; Hill et al., 2005). This model had its limitations because it does not consider the cognitive process involved in learning. The second model of research is the educational productive functions model, which tried to correlate the educational inputs with the outputs of the pupils (Monk, 1989). Some of the educational inputs include teacher characteristics (e.g. number of courses teachers have taken), pupils' socioeconomic status, and physical resources used in the actual teaching. Those studies on teachers' knowledge held the assumption that effective knowledge for teaching that would lead to learning gain depends exclusively on teachers' subject-matter knowledge (Shulman, 1986). For that, teachers had to develop a thorough understanding of their subject matter. It assumes that being well versed in the content knowledge would make a successful teacher in the classroom. The level of subject-matter knowledge would then depend on the number and quality of courses the teacher has attended (Hill et al., 2005). However, the fact that most of those quantitative studies used proxy variables (e.g. number and level of mathematics method courses taken), made those studies inconclusive due to the complexity in measuring those variables, as well as those variables being poor constructs and estimates of a teachers' knowledge (Even, 1993). Most of the past research using proxy measures concluded that the mathematics credentials of the primary teachers did contribute to pupils' academic gain (Rowan et al., 2002). For decades, this model has not been well received by some scholars within the field of mathematics education because there has been a small correlation between the number of mathematics courses taken by the teachers and the performance of their pupils (e.g. Eisenberg 1977; Begle, 1979). An important development which has paved the way for research on more effective teaching approaches has been the moving away from the single act of teaching (e.g. process-product) to the observation of patterns in teaching and learning (Borko, 2004). This leads to the design of various quasi-experimental and experimental studies to show the effect of instructional approaches on pupils' learning (Cohen et al., 2018).

3.2.3 Early Teacher Knowledge Views

A third area of research is teacher knowledge which examines what a teacher needs to know in order to be an effective practitioner. It is an irrefutable view that teachers' professional knowledge is a determining factor in the learning outcomes of the pupils. Educationists (e.g. Hill et al., 2004, 2008; Desimone et al., 2016) agree that the quality of teachers' knowledge should be addressed. Begle (1972) (as cited in Eisenberg, 1977) conducted a study to verify if there was a significant relationship between 308, 9th grade teachers' algebraic knowledge and pupils' achievement, in one academic year. Begle's findings showed no significant relationship between the algebraic knowledge of the teachers and the pupils' achievement. Begle's work was the first attempt to relate teachers' mathematical knowledge to pupils' learning outcomes. However, Begle's study was not fine-grained enough, and due to selection bias, it was replicated by Eisenberg (1977) using an unbiased sample of 28 junior high school teachers. Building on Begle's work, Eisenberg's research results indicated a small association between teachers' knowledge of subject matter and pupils' gain. Most of the early studies on quality teachers' knowledge were searching for deficits in their knowledge, rather than the type of knowledge required for learning to take place.

Later, varying perspectives on teachers' knowledge for teaching, particularly Elbaz (1983), Schön (1983), Shulman (1986), among others were introduced in the educational research arena and each one defined knowledge differently (Ponte and Chapman, 2006). Elbaz concluded that such knowledge is based on several teacher constructs such as first-hand experience, knowledge of subject matter, and instruction. Schön, claims that teacher knowledge includes RP and goes beyond content and pedagogical knowledge. Such knowledge includes the ability to solve a teaching problem through the construction of knowledge. Schön's contribution is crucial to this study because his seminal work about the way teachers reflect on their practices is a framework which partly underpins this research. However, early in the 1980s, teacher knowledge for teaching was still a 'missing paradigm'. A few years later, Shulman (1986) addressed teachers' knowledge which stood in sharp contrast with Elbaz and Schön's work, by drawing attention to studies which would address the "teachers' ability to understand and use subject-matter knowledge" (Hill et al., 2005:3). Shulman proposed the idea that teachers need special pedagogical knowledge that is unique to teaching which he termed as Pedagogical Content Knowledge (PCK). Following Shulman's knowledge perspectives, various early studies were conducted to address teachers' knowledge for teaching. A number of those are deficiency-oriented studies which have focused on the lack of teachers' mathematical knowledge (e.g. Ponte and Chapman, 2006; Nason, Chalmers and Yeh, 2012; Tatto et al., 2012). Shulman (1987) categorises different types of knowledge which he considers to be crucial for classroom teaching. His work is presented in the next section.

3.2.4 Current Perspectives of Teacher Knowledge

Shulman (1986) reframed and revolutionised the conceptual understanding of teachers' knowledge for teaching by first introducing and defining three categories of Content Knowledge (CK) necessary for a teacher to be successful in the classroom: (i) Subject Matter Knowledge (SMK), (ii) PCK and (iii) Curricular Knowledge. CK is "the amount of and organisation of knowledge per se in the mind of the teacher" (Shulman, 1986:9). It is what is taught about the subject, and it contains facts and concepts about the subject area. Such knowledge also includes how the subject is organised. SMK is the knowledge of the subject the teacher is going to teach. PCK is the understanding of the subject content in regard to its classroom teaching. PCK also involves understanding what makes the learning of a particular subject content easy or difficult and the concepts and pre-concepts pupils of different ages have when learning the materials. SMK and PCK are two central categories that Ball et al. (2008) used to reconceptualise MKT. Curricular Knowledge involves the knowledge of the curriculum, and its various materials, needed to deliver subject content at a particular level as well as lateral curriculum knowledge.

Shulman (1987) refined his previous three categories of teacher knowledge into seven other categories of knowledge necessary for effective teaching. Out of the seven categories of knowledge, PCK is considered to be the most important for teaching and has grabbed a lot of scholarly attention. It is a type of content knowledge that is unique to teaching. Shulman (1987:8) defines PCK to include "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction". A number of scholars (e.g. Baumert et al., 2010) now argue that without PCK, just the use of advanced content knowledge of the subject would be of restricted value to classroom teaching, and that PCK is an important construct in a teacher's arsenal for teaching (Van Driel and Berry, 2012; McCray and Chen, 2012; Campbell et al., 2014). However, Kind (2009) argues that teachers are not born with PCK. Rossouw and Smith (1998) suggest that teachers eventually develop their own PCK, shaped by their own experiences and perceptions. Research findings are still ambiguous and sometimes conflicting pertaining to teachers' PCK and pupils' performance (Ball et al., 2008). However, in the debate about pedagogy reform, PCK is one component of teachers' knowledge which has been identified as essential and has been positively linked to pupils' performance (e.g. Schoenfeld, 2010; Keller et al., 2017). For example, Hill, Rowan and Ball (2005) show a correlation between teachers with increased MKT and pupils' performance. Studies (i.e. Baumert et al., 2010; Martínez, and Mellado, 2016; Kultsum, 2017; Grobschedl et al., 2019) affirm that PCK is an influential component of teachers' knowledge which is fruitful for classroom teaching. A large number of studies on PCK have emerged (e.g. Ball, Thames and Phelps, 2008; Baumert et al., 2010; Lannin et al., 2013; to name a few). These studies have refined and added other dimensions and definitions to Shulman's original work, further exploring and interpreting PCK, both theoretically and empirically. Research on PCK is still ongoing and evolving (e.g. Widodo, 2017; Nind, 2020). Yet, despite the use of different research approaches, no general conclusion has been drawn and much of the contention is linked to the lack of understanding between PCK and other areas of teachers' knowledge (Doyle et al., 2018).

3.2.5 Issues round Pedagogical Content Knowledge

Shulman (2003) re-worked his original model to include the constructs previously left out; and for the purpose of this study two other constructs being emphasised are thoughts and actions of the teachers. However, Shulman's framework has also been criticised by other scholars working in the field of PCK (e.g. Ball et al., 2008; Baumert et al., 2010). For example, Baumert et al. (2010) are sceptical as to whether PCK and CK could be theoretically and empirically distinguished. As outlined by Depaepe et al. (2013), one of the strong criticisms levelled against PCK has been the lack of theoretical and empirical grounding of PCK that would make it distinguishable from Shulman's other teachers' knowledge types. According to Ball et al. (2008), such weakness in Shulman's knowledge framework calls for its further development.

3.2.6 PCK Development

Cancoy (2010) argues that without training to develop their PCK, both novice and experienced teachers would rely on procedural knowledge and memorisation. Hence, scholars have identified several sources from which PCK can be developed. Shulman (1987) recommends teacher reflection as a way of classroom practice reform. Van Driel and Verloop (1998) identified reflection on educational practice as a source for PCK development in teachers. More recently, Evens et al. (2015), in their review of PCK development sources, found reflection on educational practice to be one of the most effective means. Moreover, several educationists and scholars have written about the positive impacts of reflection on the learning process (e.g. Dewey, 1933; Schön, 1983, 1987; Brookfield, 2005; Korthagen and Vasalos, 2010; Harvey et al., 2016; Cavilla, 2017). Literature shows that RP improves the PCK of teachers. RP involves the act of teaching, and then thinking about how to improve it further, which is central to the teaching and learning process (Brookfield, 2005).

Despite the abundance of literature related to reflective practice, little has been written about how it works to develop the PCK of primary teachers. Also, a number of scholars (e.g. Baumert et al., 2010; Kunter et al., 2013; Kleickmann et al., 2013; Ma'rufi, and Ilyas, 2019) are in agreement that PCK is one of the most influential constructs of teachers' knowledge leading to effective instruction, teachers' development, and an increase in the mathematics learning outcome of pupils. For example, in the 2010 study by Baumert et al., on MKT conducted with secondary school teachers in Germany, they reported that the

PCK and CK of the teachers were distinguishable from one another and teachers' PCK affected the mathematical outcomes of their pupils. Similarly, in the 2013 study by Kunter et al. (2013) with 194 German secondary school mathematics classes, findings revealed that teachers' PCK had positive effects on instructional quality, and on pupils learning outcome, contrasting with teachers' general ability which did not affect their teaching. More recently, Ní Shúilleabháin (2016) conducted a study using the lesson study professional development approach to investigate the PCK development of 12 post-primary Irish teachers. Ní Shúilleabháin used Ball et al.'s (2008) MKT model as the analytical framework to analyse the data. The analysis revealed distinct features of MKT including PCK in the planning and reflection discourse of the teachers, thus exhibiting increased teacher learning. The fact that recent researchers are still reporting the positive effect of PCK on learning outcomes, the hypothesis is that investing in the development of PCK-type knowledge for the teaching of mathematics could improve the learning outcome of pupils. It is therefore felt that further research is needed in the area of teachers' MKT, in this specific case PCK, of primary mathematics teachers. PCK is a subset and major category of Ball et al.'s (2008), MKT framework, and a focus of this study, and is described in greater detail in Section 3.3.

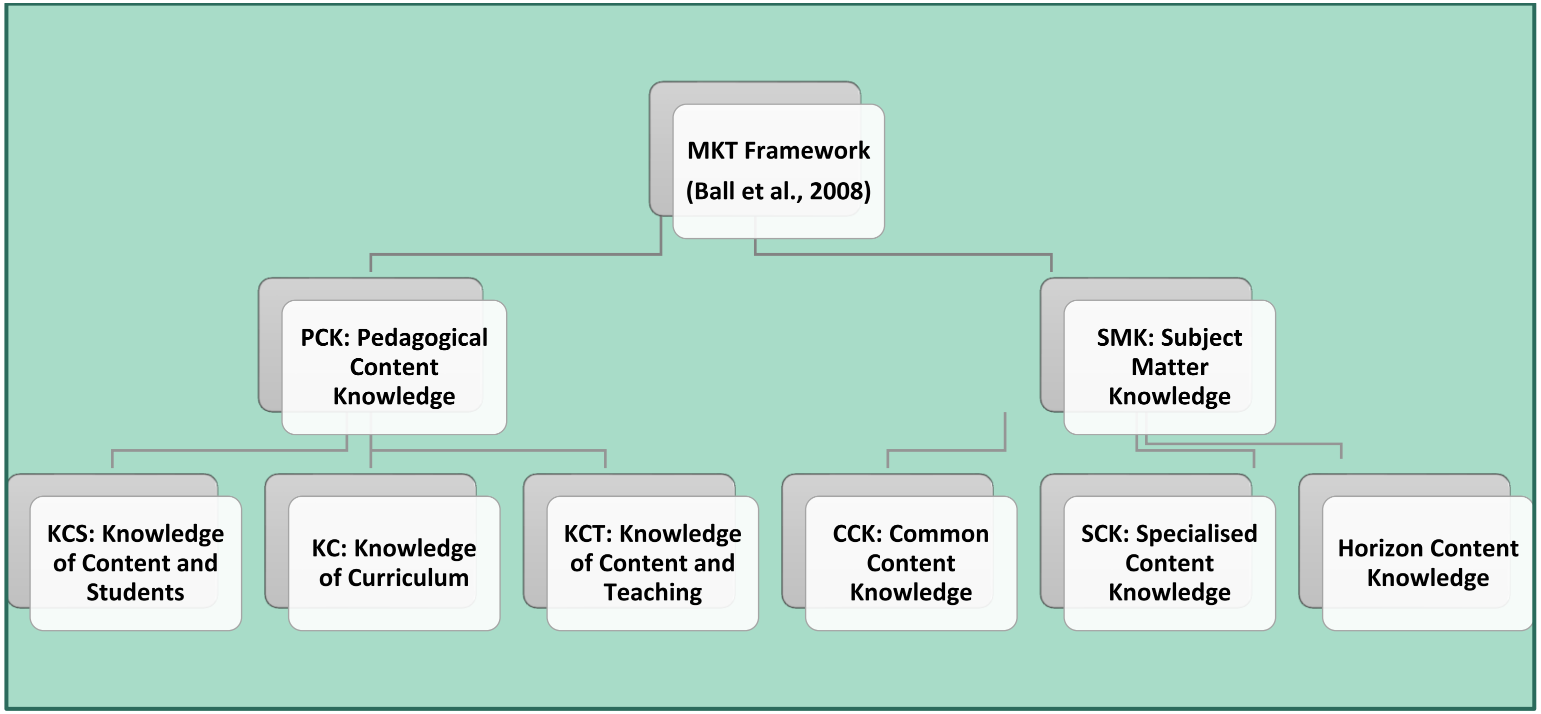
3.3 Theoretical Framework of Knowledge for Teaching

Since the conceptualisation of PCK by Shulman (1986,1987), scholars have developed knowledge frameworks with the aim of better representing the content of teachers' knowledge (i.e. Fennema and Franke, 1992; Davis and Simmt, 2006; Petrou and Goulding, 2011; Ball et al., 2008). Davis and Summit's (2006) work is an early attempt to address the type of mathematics teachers need to know. More recently, McCrory et al. (2012) investigated a knowledge base framework to teach algebra. However, the three attempts that are most influential are seen in the seminal work of Schoenfeld (2002), Rowland et al.'s (2005) knowledge quartet framework, Davis and Simmt, (2006), and Ball et al.'s (2008) MKT framework. This study focuses on the latter framework in the next section.

3.3.1 The MKT Framework

Ball, Thames, and Phelps (2008) built on the seminal work of Shulman (1987) and developed a practice-based model to frame all the knowledge types that could make the teaching and learning of primary mathematics successful. Ball et al.'s (2008) MKT framework (see Figure 3.1) depicts non-overlapping categories of subject matter knowledge (SMK) and pedagogical content knowledge (PCK) specific to the teaching of primary mathematics. They coined the model as Mathematical Knowledge for Teaching (MKT), which is a derivative and refinement of Shulman's idea of SMK and PCK (Leavy et al., 2018a). The aim of the framework was to make explicit the types of knowledge required to effectively teach primary mathematics. They defined MKT as "the mathematical knowledge needed to carry out the work of teaching mathematics" (Ball et al., 2008:395). The framework which is a reconceptualisation of PCK has two major categories or domains: SMK and PCK. The two main domains are then classified further into six other sub-domains. SMK is divided into three sub-domains: Common Content Knowledge (CCK), Specialised Content Knowledge (SCK) and Horizon Content Knowledge (HCK). Similarly, PCK is divided into three sub-domains: Knowledge of Content and Students (KCS), Knowledge of Content and Teaching (KCT), and Knowledge of Curriculum (KC). The MKT framework is depicted in Figure 3.1 below.

Figure 3.1: MKT Framework (Ball et al., 2008)



Common Content Knowledge

CCK is "the mathematical knowledge and skill used in settings other than teaching" (Ball et al., 2008:399; Kuennen and Beam, 2020). From the SMK category, CCK is the knowledge of mathematics that most school graduates would possess. For example, most mathematics graduates should be expected to apply Pythagoras' Theorem: ($c^2 = a^2 + b^2$). It is a knowledge type that is not just common or unique to teaching. Such knowledge is also common to people in fields such as engineering and other sciences. Even if CCK is not common to teaching, such knowledge is essential to teaching, and teachers should understand the mathematics they are delivering to the pupils (Kelcey, Hill, and Chin, 2019).

Specialised Content Knowledge

SCK is a special type of mathematical knowledge for teaching only, which is not necessarily accessible to other mathematicians. It is "the mathematical knowledge and skill unique to the work of teaching" (Ball et al., 2008:400; Ding, 2016; Yee Lai and Clark, 2018), and is not necessarily required in other settings outside mathematics teaching. This would entail the evaluation of the pupils' responses and answering their 'how' and 'why' questions. SCK is a special type of knowledge and different from conceptual knowledge that helps teachers to answer the how and why of teaching. For example, only a teacher would need to explain to a learner the logic in the long division algorithm. It is worth mentioning that the boundary between CCK and SCK is blurred and SCK may differ across countries and levels of teachers (Delaney et al., 2008; Leavy et al., 2018a). Ding (2016) investigated the development of pre-service elementary teachers' SCK for teaching the associative property of multiplication. The findings of the study revealed that SCK was slowly acquired and thereafter developed further. Recently, Kuennen and Beam (2020) argued that a well-designed course content can help prospective teachers develop their SCK.

Horizon Content Knowledge

HCK refers to the knowledge of how the mathematics topics are linked and organised in the school curriculum; "an awareness of how mathematical topics are related over the span of mathematics included in the curriculum" (Ball et al., 2008:403). Such knowledge is not deployed directly in teaching. In the practical teaching sense, it is the teachers' theoretical perspectives of the layout of the topics behind and beyond the one being taught (Ball and Bass 2009; Jakobsen, Thames, and Ribeiro, 2013; Mosvold and Fauskanger, 2014). However, some scholars (e.g. Jakobsen et al., 2012) insist that the nature of HCK is still unclear.

Knowledge of Content and Students

KCS is knowledge of both mathematics and the students. It is the knowledge of how a pupil learns and thinks about a particular subject. Hill et al. (2008:375) define KCS as "content knowledge intertwined with knowledge of how pupils think about, know, or learn this particular content". Ball et al. (2008), and Kuennen and Beam (2020) explain that KCS is the knowledge of misconception and difficulties, the types of question that a pupil would have when learning a piece of content, and what they are likely to think. To a large extent, it is about teachers' anticipation of how their pupils would react to particular learning materials. Lannin et al. (2013) found their version of KCS to be a pivotal factor in the development of teachers' PCK.

Knowledge of Content and Teaching

KCT, as another sub-domain of PCK in the framework, is the knowledge of how contents interact with pedagogy for learning to take place. Ball et al. (2008) explain it as knowledge about the combination of teaching and mathematics. Based on Shulman's (1986) concepts of KCT, such knowledge allows the teacher to design appropriate learning materials for their pupils. For example, the teacher should be able to select appropriate mathematical content in order to move the pupils from the known to the unknown. Teachers who are well developed in their KCT should be able to understand how to combine their mathematical content knowledge with instructional practices which facilitate the learning of their pupils.

Knowledge of Curriculum

KC refers to the interaction between knowledge of mathematics curriculum content and its standards (Kuennen and Beam, 2020). It is important for a teacher to have a sound knowledge of the curriculum. The curriculum is the programme and range of materials designed to teach a subject at a specific level (Shulman, 1986). KC allows the teacher to be familiar with the mathematics curriculum.

The MKT framework is still open to refinement and further research. Ball et al.'s (2008) MKT framework is crucial for this research, as it helps to frame and discuss the various areas of knowledge involved in the teaching of primary mathematics. Ball et al.'s MKT framework advocates that mere common mathematics content knowledge of teachers is not the solution and not enough for effective mathematics teaching. Instead, teachers need more specialised knowledge. In this research, MKT is understood as the specialised mathematics knowledge group that teachers refer to when teaching. MKT is currently in its evolving stage and is considered as one of the most promising knowledge frameworks. Current literature (e.g. Hoover et al., 2016) reveals that scholars and researchers are increasingly keen to understand how MKT impacts learning. In addition, Hill et al. (2004) and Ball et al. (2008) call for further testing of the model. In this research, RP is used to explore the development of the MKT sub-domains of primary mathematics teachers. Turner (2012) uses the MKT framework to ground investigation of MKT development of new elementary teachers in England. In this research, the MKT framework is used to situate, connect, and discuss teachers' mathematical knowledge.

3.3.2 Critiques of MKT Framework

MKT has been linked to pupils' performance. For example, Hill and Charalambous (2012) found that teachers with stronger MKT were able to provide high-quality instruction. However, some scholars have had some concerns about the MKT model and have levelled multiple criticisms against it. Ball et al. (2008) self-critique their framework by acknowledging that there could be some boundary problems between some of the sub-domains in the framework. Also, Hurrell (2013) and Thanheiser et al. (2010) share the criticism that there is a fine line between CCK and SCK. Furthermore, Hurrell (2013:60) revises the MKT framework and goes on to say that the unproportionable space occupied by the components in the original MKT diagram (Hill et al., 2008:377) could lead to the inaccurate interpretation of some components in the framework being more important than others. The MKT framework has also been criticised for the exclusion of teachers' beliefs (e.g. Beswick, 2012).

3.3.3 Measuring Teachers' MKT

Despite its short historical conceptualisation, much work has been done to produce instruments to measure MKT. Using a quantitative methodology, Hill, Schilling and Ball, 2004 developed and validated sets of multiple-choice items which they called 'Learning Mathematics for Teaching' (LMT), items to measure the MKT of some teachers across two elementary grade levels in the USA. From the results of their study, they concluded that MKT directly impacts on elementary pupils' performance and is therefore a significant predictor of pupils' outcome. The LMT tool has since been adapted by researchers inside and outside the USA to examine the MKT of teachers, and other have been developed to measure MKT: for example, the LMT instrument (e.g. Hill, Rowan, and Ball, 2004; 2005; Krauss et al., 2008; Hill, Ball, and Schilling, 2008); the COACTIV project (e.g. Baumert et al., 2010; Kunter et al., 2013) for secondary teachers; Campbell et al. (2014) developed an instrument to measure the MKT of early-career teachers. Their findings showed teachers' mathematical content and their PCK had a positive association with their pupils' learning outcomes. Such studies suggest that MKT is measurable through paper-based tests despite challenging anomalies.

The literature does reveal various challenges when measuring teachers' knowledge. One of the major challenges is that most countries do not have prepared and validated test items, and any assessment tool which is developed quickly would need time to be polished (Hsieh, 2013). The use of an assessment tool (e.g. LMT) to assess primary teachers' knowledge was later criticised by various scholars (e.g. Schoenfeld, 2007; Rowland et al., 2009). The argument levelled against the use of the LMT is that it does not necessarily assess the practical performance of the teachers.

3.3.4 Some Studies on Teachers' MKT

Copur-Gencturk's (2012) doctoral research investigated the relationships between teachers' mathematical knowledge, their teaching practices, and pupils' achievement of twenty-one in-service teachers as they participated in a Master's degree programme. The four-year, mixed-methods longitudinal study had the purpose of examining how teachers' MKT changes over time to affect instructional practices. The instruments used to collect data were linear growth model, observations, and interviews. The results of the study indicated a marked increase in teachers' mathematical knowledge, an interesting change in their "lesson design, mathematical agenda of the lessons, task choices, and classroom climate" (ibid:3). Copur-Gencturk elaborated that teachers need strong mathematical knowledge to make significant changes in their practices. Jacob et al. (2007) conducted a study in the USA investigating the impact of a PD programme on teachers' MKT. The findings revealed very little effect of the PD programme on the MKT of the teachers, and no effect on classroom instruction and pupils' outcomes. However, the three-year study suffered from a waning of support for the project during the last two years, causing the results of the findings to be questionable. More recently, Lee et al. (2018) investigated teachers' SMK, KCT, and KCS for problem posing. The purpose of the study was to investigate teacher knowledge for teaching in problem posing. Using a qualitative design and interview methods, the researchers applied inductive analysis to interpret interview data from four intermediate, middle, and high school participant teachers in Korea. The findings of the study indicated the participants had KCT and KCS of problem posing and were aware of the significance of problem posing for pupils' mathematical development, as well as the importance of problem generation and reformulation. Studies have previously used mixed methodology to look at MKT development of teachers. For example, Nolan et al. (2015) used a mixed methodological approach to explore the MKT development of two groups of (n=30) Irish in-service teachers. Findings revealed more than half of the sample showed significant change in their MKT level in terms of the concept of fractions and its teaching. The study also revealed a marked change in teachers' awareness of MKT, with the participant teachers being more aware of the learners' roles and needs. Dempsey and O'shea (2017) used a similar mixed methods approach with a group (n=19) of Irish pre-service teachers and found that the participants were able to design and classify teaching tasks much better. The results also showed significant change in their PCK which was linked to cognitive demand. Most recently, Kuennen and Beam (2020) used problem-solving based tasks to develop the MKT (e.g. SCK) of prospective elementary teachers in the USA.

3.3.5 Studies on MKT in the African Context

MKT in the African context is worth considering because the quality of teachers is reported to be lower in a number of African countries (e.g. Kisirkoi and Kadenyi, 2012), and teacher quality has been reported to correlate with instructional practices as well as being a determinant factor in pupils' learning outcome. According to a review conducted by Hoover et al. (2016), most studies on MKT between 2006 and 2013 were conducted in the USA, Europe and Asia, with only seven recorded in the African region. Jakobsen and Mosvold (2015) also conducted a review of MKT studies in Africa and found the same number of MKT studies as Hoover et al. (2016). Most of them were qualitative studies conducted with in-service teachers in secondary schools. Jakobsen and Mosvold (2015) recommended that more research on MKT in primary teachers should be conducted in Africa. In spite of a plethora of international studies in the area of teacher knowledge, there does not appear to be specific research conducted to address the MKT of primary teachers through RP. However, a few MKT studies have been conducted in mainland Africa (e.g. Moru, Qhobela and Maqutu, 2014; Abdulhamid and Venkat, 2014; Bowie, Venkat and Askew, 2019). In addition, South African researchers (e.g. Askew, Venkat and Mathews, 2012; Venkat and Naidoo, 2012) have linked crisis in mathematics education in South Africa to limited MKT of teachers. Using SACMEQ data, Venkat and Spaull (2015) found gaps in South African primary teachers' MKT. Sapire and Sorto (2012) compared two parallel studies concerning the quality of mathematics teaching conducted in the northwest province of South Africa and southeast Botswana, involving a total of 183 teachers. Results of these studies showed that the grade six classroom teachers exhibited a lack of knowledge of how to combine mathematical content with effective teaching strategies. In a study conducted by Moru et al. (2014) in some primary schools in Lesotho, the knowledge of thirteen teaching assistants was enhanced by the use of lesson study. Lesson study has been shown to be effective in enhancing the MKT of in-service teachers. Lesson study involves the process of joint planning and delivery of lessons by teachers. It has been proven to help teachers improve their practice. Using an interpretive paradigm, Moru et al.'s research investigated how teachers viewed the impact of instruction on enhancing their MKT. The participants developed, taught, and reflected on their lessons. Moru et al. (2014) used the seminal works of Ball et al. (2008) and Skemp (1976) as the basis for their exploration. The findings indicated a significant change in the

MKT of the participants. The gain in teachers' knowledge was attributed to their engaging in RP and teaching for relational understanding. The methodological strength of the study is accredited to the researcher's view on the nature of learning mathematics which could be described as a reflective interactive discourse approach. The use of RP and teaching for relational understanding (Skemp, 1976) in the lesson study fully engaged the participants in the activities, thus resulting in change in knowledge. The main argument in this research is the importance of RP as an agent of change in teachers' knowledge. Moru et al.'s study has two main strengths. Firstly, it provides evidence that teaching assistants, who can be classified as practitioners, can enhance their mathematical knowledge through the lesson-study approach involving RP. Secondly, it displays a replicable strategy of making teachers aware of their weaknesses from the outset and works with them towards change. In summary, the study informs future researchers of the effectiveness of reflection in the lesson-study approach in order to enhance the mathematical knowledge of teachers. However, it was a qualitative study where, arguably, a mixed methodology would have been better, where the qualitative component of the study would have complimented the qualitative component. The study also limited itself by not stating a clear framework to underpin the research. Although it remains unclear how the reflective process improves teachers' knowledge, it is plausible that group interaction has played a significant role. Additionally, the study suffered a setback in the methodology, which is described by the researcher as a challenge "to know if what the teachers say matches what they do". This challenge would have been eradicated if the study design had involved a type of triangulation process. Two underlying themes which come out of Moru et al.'s study in relation to the enhancing of teachers MKT are reflection and relational understanding. The reflection theme also appears in other recent studies on MKT enhancement (e.g. Moscardini, 2014; Deshler, 2015 and Lomibao, 2016), where the reflective component of their studies helped to improve the mathematical knowledge of the teachers. A number of other studies have used lesson study as an approach to improve teachers' mathematical practice (e.g. Sudejamnong et al., 2014; Ní Shúilleabháin, 2015; Lomibao, 2016; Clivaz, 2017). In another study by Abdulhamid and Venkat (2014) in South Africa, the authors examined how the MKT of primary teachers can be developed in research-led ways. The authors stated that previous related study conducted by Venkat and Naidoo (2012) did not directly focus on MKT, but revealed gaps in both SMK- and PCK-related issues of the teachers. Therefore, further research was required to investigate the MKT of the teachers in the areas of the nature of mathematics, task sequencing and connecting. The authors used Rowland et al.'s (2009) 'knowledge quartet' (KQ) framework to underpin their study. The data from the lesson observations and video-stimulated recall interviews indicate significant change in the MKT of the teachers. The key insight of the study is that the MKT of primary teachers is still being researched, and the findings of that study add to the current knowledge that MKT can be enhanced through RP. While they produced an important finding, they neglected to introduce a quantitative perspective to the study. The authors make recommendations for longitudinal study in order to confirm the transferability of the knowledge gained by the participants. The strength of this study is that it provides evidence that the assumed knowledge and skills held by teachers can be developed into productive classroom knowledge if they are supported and encouraged to reflect on their practices. The similarity between the studies of Moru et al. (2014) and Abdulhamid and Venkat (2014) is that both used RP to improve the knowledge of primary teachers. Both groups of researchers acknowledged the fruitful contribution of RP to their study. Recently, Bowie, Venkat, and Askew (2019) studied the MCK of pupil teachers in South Africa and found that they lacked key mathematical concepts. To conclude, it is argued that the dearth of MKT studies in developing countries, such as those on mainland Africa and in Seychelles, could suggest that both teacher-training institutions and teachers in Africa are not aware of the various studies on MKT and its relevance to mathematical development in their countries.

3.3.6 Professional Development and Growth of Teachers' Knowledge

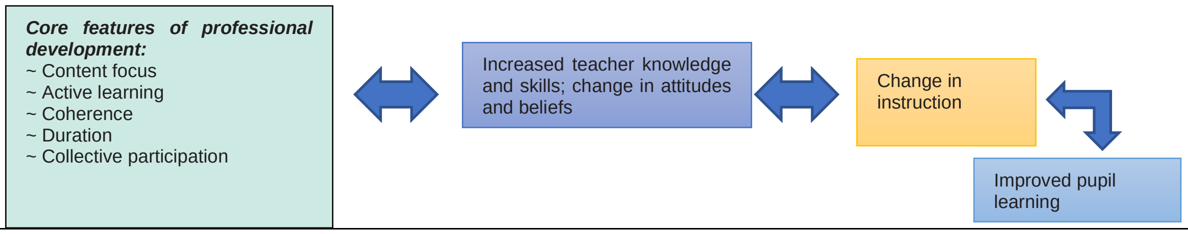
Bautista and Ortega-Ruíz (2015) explain that during reforms of educational systems most educators and scholars agree that addressing the PD of teachers should be a priority. For example, teachers in Lingam et al.'s (2017:19) study made recommendations for continuous professional development so that they could "cope well with new demands of work". Hattie (2003:2) concludes that besides pupils themselves (50%), the teacher, with a variance of 30%, is the next major agent in successful learning, and argued that "what teachers know, do, and care about is very powerful in this learning equation". Also, educational scholars (e.g. Borko, 2004; Desimone, 2011; Zhukova, 2018) explain that effective PD of teachers, or self-initiated activities, are critical to the holistic improvement of schools, including where teachers can enhance their knowledge, instructional practices and pupils' learning outcomes.

Despite the decades-long history of PD in schools, there are only certain perceived characteristics of effective PD that are thought to lead to the growth of teachers' professional knowledge and a change in pupils' learning. Effective PD programmes can lead to change in learning outcomes of pupils if their activities are effective (Timperley et al., 2007; Desimone, 2009). In this research, the term 'Professional Development' is used to define the act of helping practicing teachers to improve the teaching and learning outcomes of their pupils. Teacher PD can be conducted in various forms such as workshops, conferences, seminars, action research, discussion with other teachers, lesson study, reflecting on lessons, team teaching and so on. The education community is now advocating a more progressive model of effective PD to include recommended characteristics of effective and non-traditional professional development (Desimone, 2009; Desimone, 2011; Desimone and Stuckey, 2014; Chen, 2014; Darling-Hammond et al., 2017). After numerous rigorous studies of teacher's PD programmes (e.g. Lindvall, 2017; Karsenty, 2018; Bonghanoy et al., 2019), there is now a consensus to focus on the effective features of a PD model rather than on its structure. As one example, Desimone (2009) lists five core features of effective PDs in her conceptual framework to guide the PD of teachers. The features are content focus, active learning, coherence, duration and collective participation (see Table 3.1).

Table 3.1: Desimone's (2009) core features of effective PD

Core Features of Effective PD	Description
Content focus	Subject matter content and how pupils learn that content
Active learning	Teachers actively interact with their own designed pupil activities and learn from them
Coherence	PD being consistent with other school affairs
Duration	Enough time for professional development to take effect
Collective participation	Community of practice among teachers

Desimone's (2009) framework for Professional Development



Desimone's four components of her PD framework, and their respective features are explained in more detail in Chapter 4 as a conceptual framework for this study (see Section 4.2). However, some studies (e.g. Garet et al., 2011; Rockoff et al., 2011) have reported that the application of this type of PD framework has not been so fruitful. In their 2011 study of rational numbers, Garet et al. reported the PD programme did not have a significant impact on teacher knowledge or on pupil achievement. Other scholars and researchers (e.g. Guskey, 2002; Clarke and Hollingsworth, 2002 and King, 2014) have produced quite similar PD frameworks. Nevertheless, emerging studies suggest that there are particular ways that PD impacts both on teacher knowledge and pupils' learning outcome or makes teachers' PD effective. Hightower et al. (2011) explain that before PD can impact pupils' learning, it must first improve teachers' knowledge and skills (Hightower et al., 2011:12). Blank and Alas (2009) in their review of effective PD design found that the PDs that are promising are those which plan for teachers to have specific subject and pedagogical instruction on how to teach the subject content, followed by its implementation support. Scholars (e.g. Desimone, 2011: 68-69) suggest that effective PD should transform teachers' knowledge in a way that it transcends into enhanced learning outcome.

3.4 Theoretical Perspectives on Teacher Reflection

It is not possible to provide and discuss here the plethora of literature on reflection, but a review of the most relevant to this research is included. Scholars and educationalists have long acknowledged, accepted, and credited the benefits of reflection and its impact on teacher development. For example, in 2006 the American National Council for Accreditation of Teacher Education (ANCATE) established a standard in its charter that required their pre-service teachers to practice reflection (Lai and Calandra, 2010). There is now a wealth of literature on reflection, reflective teaching and RP (e.g. Black and Plowright, 2010; Liu, 2015; Slade et al., 2019).

3.4.1 Historical Context and Definitions of Reflection

The history of reflection can be traced to its intellectual origin in the work of Plato, but reflection and RP of teachers in education, or reflective teaching, can be traced back to the work of John Dewey (1933) and Donald Schön (1983, 1987) amongst others. Within the literature of RP, there is the assumption that it is a contentious concept and quite challenging to define, thus lending itself to multiple interpretations (Korthagen, 2004; Marcos et al., 2009; Black and Plowright, 2010). Literature reveals that the terms reflection, critical reflection, reflective learning, reflective teaching, RP, are polysemic, disputed and contested concepts. They are being used interchangeably without significant distinctions between them (Black and Plowright, 2010). Also, different scholars characterise them differently, and from their own perspective and worldview (Zeichner and Liston, 1996). In this research, the reflection concept focuses on developing teachers' reasoning on what they have taught in the classroom, and how they can improve their performance. The term reflection is derived from the Latin word 'reflectere' meaning 'to bend back'. In literature, different definitions of reflection are provided. For instance, Shulman (1987:10) is of the view that reflection is a process where the teacher "looks back at the teaching and learning that has occurred, and reconstructs, re-enacts, and recaptures the events, the emotions, and the accomplishments". Daudelin (1997:39) posits that reflection is "the process of stepping back from an experience to ponder, carefully and persistently, its meaning to the self through the development of inferences". Black and Plowright (2010:246) provide a more appropriate definition of reflection as follows:

> *Reflection is the process of engaging with learning and/or professional practice that provides an opportunity to critically analyse and evaluate that learning or practice. The purpose is to develop professional knowledge, understanding and practice that incorporates a deeper form of learning which is transformational in nature*.

Black and Plowright's (2010) definition influences the interpretation of reflection for this research, and best describes the researcher's current views of RP which underpin this study. Therefore, in this study, reflection is defined as a process where the teachers engage with their teaching through the critical analysis and evaluation of their instructional practices, with the purpose of developing professional knowledge and practices. However, evidence from literature affirms that historically there have been problems and difficulties in conceptualising the terms reflection and RP and their encapsulation. Zeichner and Liston (1996) point out that the divergent interpretations of reflection are the echoes of the various traditions in the conceptualisation of such a idea. Pollard et al. (2005) provide a model that informs the various traditions of RP, and consequently explain its various historical definitions and interpretations. The traditions in the model are academic tradition, social efficiency tradition, social re-constructivist tradition and developmentalist tradition. The model also provides seven constructs of RP which are: aims and consequences, evidence-based classroom enquiry, open-mindedness, responsibility and whole-heartedness, application of judgment based on enquiry and research, collaboration and dialogue with colleagues, and creative mediation of externally developed frameworks. In the above discussion on the history of reflection, there is an evident gap in the literature with regards consensus of its definitions (Cornish and Jenkins, 2012). However, while those definitions define reflection in different contexts, conversely, they are united in terms of having the ultimate intention of changing teachers' practices. Despite the dissonance in definitions, reflection provides many advantages to the individual teacher, and a step to becoming a professional practitioner.

3.4.2 Types of Reflection

This research explores the effects of reflective practice (RP) on the MKT and mathematics self-efficacy beliefs of primary teachers. From an educational perspective, RP is an act where the teacher continuously re-examines what has happened in the classroom with the intention of making it better the next time around. It "is learning from experience in order to improve practice" (Bassot, 2016:1). Various other scholars have also defined the term RP. For example, Mathew and Peechattu (2017:27) define reflective teaching practices as "a process where teachers think over their teaching practices, analyse how something was taught, and how the practice might be improved or changed for better learning outcomes". This study supports and focuses on Bassot's (2016) definition of RP which is focusing on learning from experience in order to improve practice. Gungor (2016) points out that RP includes critical thinking, self-direction, problem solving, and self-awareness. Critical reflection is linked and central to several theories and traditions (e.g. transformative learning theory). Taylor (2017) explains that critical reflection is central to Mezirow's (1991) Transformative Learning Theory (TLT), which is one of the theoretical perspectives underpinning this research (see Section 4.3.1). Leask and Liversidge (2013) explain that Schön (1983) first used the phrase 'reflective practitioner' to explain how enlightened professionals such as teachers work in modern society. Schön (ibid) being influenced by Dewey's work, interprets and refines Dewey's idea of reflection and places it within an educational context which, since then, has been extensively used. It was Schön who came up with the term 'Reflective Practice' and defines it as a process in refining one's discipline. Schön's definition makes RP a professional development tool for schools. Both Dewey and Schön affirm that reflective thinking is necessary for the professional growth of teachers and successful teaching. Schön posits that teachers rarely engage in vague routine action, but rather in 'knowing in action' which is knowledge drawn from their intelligence. Schön (1987) discusses three occasions or modes of reflection which are applicable to the professional development of teachers. They are reflection in action, reflection on action and reflection for action. Schön (1987) also explains that reflection allows teachers to reshape their teaching in real time (e.g. reflection in action) and after teaching (e.g. reflection on action) and in a professional context. In terms of classroom practice, reflection in action or the 'on-the-spot experiment' (Schön, 1987:25), is a type of real-time action where the teachers draw on experience, skills and knowledge to deal with a learning situation or problem. Kundin (2010:347) refers to it as "teachers thinking on their feet". This is done in the act of teaching. For example, Bolton (2014:6) emphasises that teachers cannot say to their pupils "sorry but I've got to stop and think how to do this". Teachers need to draw on their knowledge in real time as they continue to make decisions for their teaching. Bolton further explains that experienced teachers rely greatly on reflection in action; and the more experienced they are, the more they have to draw upon. Nilsson and Karlsson (2019) describe reflection in action as reflecting on the incident while it can still benefit the situation, instead of thinking how you would handle the situation differently in the future. Reflection for action guides the practitioner in a reflective process in order to make future actions. Schön conceptualises reflection in action, reflection on action and reflection for action as a continuum, where all three may happen for an incident, such that teachers can move from one end to another to gain control of their development. Schön (1983:68) argues that when teachers reflect in action, they "become a researcher in practice". Such reflection in action is important to this present study as it can help to explain how teachers reshape their thinking and plan of action. In everyday teaching, a teacher could be performing real time reflection on why a pupil is not understanding a particular mathematics concept. On the other hand, reflection on action or retrospective reflection is performed after the event, and it is a more conscious process (Harrison, 2012; Bassot 2013; Bolton, 2014; Nilsson et al., 2019). Bassot (2013:36) explains that reflection on action enables the practitioner to analyse what happened, think through the event from several perspectives, identify the things that went well, identify problems and work towards a solution where possible, identify areas for development, build one's professional knowledge, and think about what one should do next time in a similar situation. Such a process involves teachers thinking and re-examining the taught lesson in order to further improve learning in their classrooms. Impedovo and Malik (2016) remark that reflection on action is not just a thinking process, it involves feelings, emotion and decision making. However, Schon's model had been criticised for ignoring context and being unreflexive (Finlay, 2008). Van Manen (1991:101) contributes a third dimension to Schön's model of reflection, termed reflection for action or, more appropriately, 'anticipatory reflection'. Van Manen's dimension is about making inferences from existing experiences for future actions, which is also shared by Boud (2001) and Bassot (2013). Such continuous re-examination of their practice allows teachers to develop new knowledge about their teaching (Loughran, 2002).

In this research, the concept of RP is the process whereby teachers examine their lessons before, during, and after teaching a particular mathematical content area with the intention of improving practice and the learning outcomes of their pupils. Such a process may lead to change in the professional knowledge of the teachers and make them better practitioners (Slade et al., 2019). Schön's (1983) model of reflection enhances understanding in this study in terms of the types of reflection the participants could reveal in their reflective writing.

3.4.3 Inhibitors of Reflection

Literature reveals some interesting parameters that can inhibit reflection. For example, Boud (2001) argues that one of the main inhibitors to reflection is the knowledge of the person who will ultimately read the written journal. He explains that the type of audience one is writing for has as a detrimental and profound effect on what is considered in the writing.

> *For example, revealing negative feelings about the difficulties of classroom practice could have a substantial influence on how a pupil teacher is perceived by supervisors and may lead to failure to graduate.*
>
> (p.6)

Boud (ibid) elaborates that keeping the journal private could be a suitable strategy to release creativity in writing and whatever should not be revealed to a particular reader can later be censored. The other obstacle to journaling is whether the writer is writing for learning or for assessment. Boud reveals that accredited learning such as the assessment of reflective journals could be a hindrance to its writing and the development of the writer. This is due to the natural tendency of people to focus on what they know and keep away from issues (e.g. uncertainty, perplexing events) that are affecting them, which is the opposite purpose of reflection (ibid).

3.4.4 Critiques of RP and the Challenges to Schön's Theory

Despite the popularity of RP, it has been criticised by different commentators. Kinsella (2009) argues that even if there is wide use of the term reflective practice and its applications, it still has an unclear epistemological framework. Even if Schön's theory has inspired many subsequent models, his work on reflection has received some criticism. Amongst other things, he has been criticised for portraying RP as a 'solitary act' (Brooke, 2014: 51), without considering the social context of learning. In relation to this research, the researcher agrees with the model provided by Pollard et al. (2005) (see Section 3.4.1) and argues that reflection does not have to be a solitary act and that other members of the community in which the reflection occurred should also be considered. For example, Solomon (1987) argues reflection is a social practice, and discussion of ideas with others is crucial in the development of a critical pedagogical perspective. In addition, scholars (e.g. Chandler et al. 1991; Cornford, 2002; Winchester and Winchester, 2014) affirm there is little evidence to conclude that engaging in RP leads to improved learning outcomes or teaching performance; thereby questioning the validity of reflection as a professional development tool for teachers. Ekebergh (2007) contends it is not possible to be in the same environment and attempt to perform real time reflection (e.g. reflection in action). However, some of the criticisms brought forward against RP based on Schön's theory show that there are fruitful windows of opportunity to extend the theory.

3.4.5 Benefits of Reflective Practice

Some recent educational literature (e.g. Tripp and Rich, 2012a; Kramer; 2018; Walshe and Driver, 2019) still depicts RP as being important for the practicing teacher. For example, Kramer (2018) found a positive impact of RP on teachers' PD. There are many advantages of RP from which both seasoned and new teachers can benefit, if they use it. Borg (2011) acknowledges that RP allows teachers to critically examine their teaching in order to improve the quality of output. Reflective teachers are therefore those who take a problem-solving approach to their teaching, who stand back, critically analyse, and evaluate it with the intention of enhancing the output. A considerable body of research (e.g. Van Driel and Berry, 2012; Harnett, 2012; Poom-Valickis and Mathews, 2013;

Kleickmann et al., 2013) suggests teachers need to effectively reflect on their own pedagogy in order to change their current instructional practices; thus, rendering RP to be a key factor in teachers' PD in teacher education. Valli (1997:72) argues teachers "are not, and should not be, unthinking conformists", instead they are considered as problem solvers who should be able to help their pupils overcome learning obstacles. The rationale given in the literature for RP (e.g. Mathew and Peechattu, 2017) is that teaching experience alone is not enough for learning to take place but, rather, teachers have to infuse it with RP. Mathew et al. (2017) go further to explain how RP does not just involve looking back at past classroom events, but involves the use of emotions, experiences, actions and response, all of which are added to the knowledge base of the teacher in order to attain a higher level of understanding. Impedovo and Malik (2016) also explain that the objective of RP in education is to guarantee a more eloquent understanding of a classroom situation so that effective actions can be provided to strengthen pupils' performance. Sellars (2012) reports that all types of reflection in the professional contest are either to provoke change in order to improve practice, or to develop the understanding or self-knowledge of the practitioner.

Teachers should be asking the question: "What should I do next time to make my pupils understand better?" In terms of benefits, RP allows a practitioner to learn from experience and make changes to future behaviour. Kleickmann et al. (2013) argue the experience of teachers is not enough for effective teaching; instead, classroom experience should be used in conjunction with RP. Furthermore, Poom-Valickis and Mathews (2013) affirm that through reflection, teachers can interact with learners and guide instruction.

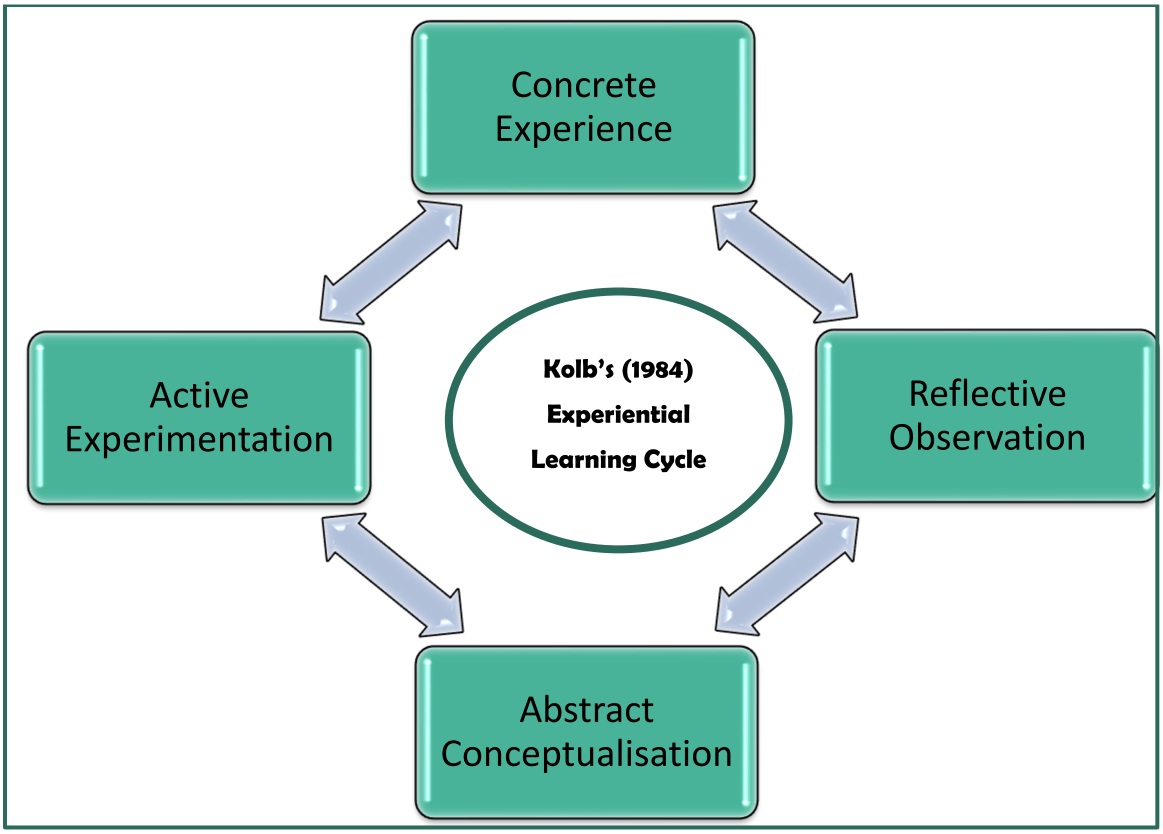
3.4.6 Models of Reflective Practice

Literature reveals various models of reflective practice that have been defined, re-reworked and which continue to emerge. Some of the widely used reflective models in scholarly literature for teacher education include Schön's (1983) Reflective Model, Kolb's (1984) Experiential Learning Cycle, Gibbs' (1988) Reflective Cycle, Brookfield's (2005) lenses, and Liu's (2015) model of transformative learning. However, the two most popular models used in education are those of Kolb (1984) and Gibbs (1988).

3.4.7 Kolb's Experiential Learning

Kolb (1984) has been much quoted for the experiential learning model and is widely used in education. According to Kolb and Kolb (2005), the experiential learning theory has been influenced by prominent scholars such as John Dewey, Carl Roger, Jean Piaget, Carl Jung, Paulo Freire and others who saw experience as being vital to human development and learning. Kolb considers reflection as an important part of learning. In Kolb's (1984) four-stage experiential learning cycle (see Figure 3.2), reflection practice is linked to learning and unfolded through a concrete experience (doing and having an experience). It then moves to a reflective observation stage (reviewing and reflecting on the experience) where the practitioner reflects on or reviews the experience. The next stage is the abstract conceptualisation (learning from the experience) where the personal value of the experience is considered. The final stage is the active experimentation (trying out what one has learnt) where the practitioner puts into practice the new knowledge.

Figure 3.2: Kolb's (1984) Experiential Learning Cycle

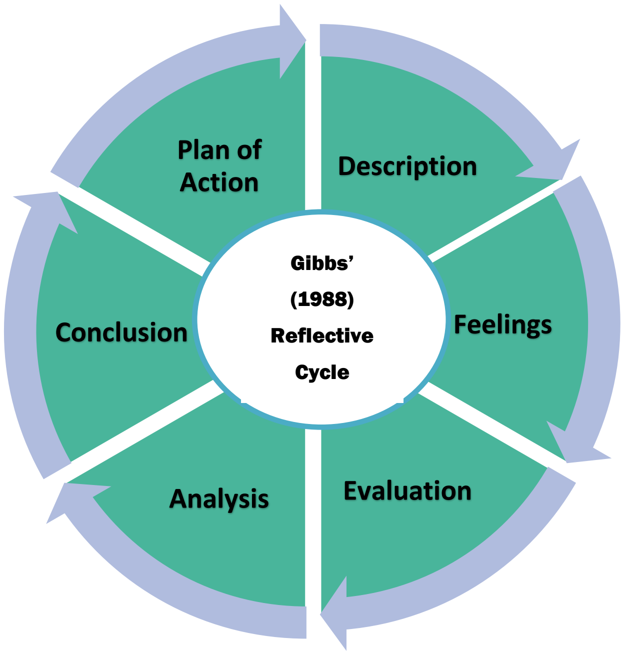


Kolb later modified his 1984 model but adopted the same four learning constructs. Some criticisms levelled against Kolb's (1984) model is that learning does not necessarily occur in sequential steps. Bergsteiner et al. (2010) argue that some recognised learning styles are absent from Kolb's (1984) model. Korthagen (2001) criticises Kolb's (1984) model for misjudging the role of the individual in the learning process.

3.4.8 Gibbs' Reflective Cycle Model

Gibbs' model (see Figure 3.3) is a derivative of Kolb's (1984) Experiential Learning Cycle. It is drawn on research and provides a structure for how to effectively reflect on experiences (Gibbs, 1988).

Figure 3.3: Gibbs' (1988) Model of Reflective Cycle



Gibbs' (1988) Reflective Cycle Model has been adopted to guide and structure the reflection of the teachers in this research. From the earlier Latin definition of reflection, reflective teachers are those who 'bend back' (Section 3.4.1) or carefully think back to their teaching with judgment. For the purpose of this study Gibbs' model was chosen alongside Kolb's (1984) and the other models because it is considered to be appropriate for teachers when factoring in their feelings and emotions; as well for using simple language and clear concrete steps for primary teachers to implement. Gibbs' model involves a cyclical process and makes use of six stages to effectively review, analyse and evaluate an activity or experience in order to learn from it. The six stages are description, feelings, evaluation, analysis, conclusion and action plan. For the description stage the practitioner should provide a detailed and concise description of the experience or incident that has troubled or interested them. Therefore, some of the prompt questions at this stage are: What happened? Who is also involved? How did it happen? Smith et al. (2015) point out that the description process might be more challenging as it is not always easy to separate analysis from description. Hanuscin (2013:937) explains that "growth in one's knowledge for teaching comes about when reflection on critical incidents involves challenge to and critique of oneself and professional values, which in turn can lead to changes in practice". This phase uses a significant experience or incident to ground the critical reflection process as well as for the practitioner, such as pupil teachers, to learn from (Nilsson et al., 2019). The phase is crucial because any change in the MKT of teachers would be captured when critically reflecting on a classroom incident. An example of MKT being captured through reflective practice could be in the form of KCT; if teachers refer to new approaches to teaching word problem solving strategies, as well as possible teaching difficulties. The description phase was criticised by Bentham (2004) who argued that describing a negative critical classroom incident could lead to an inferiority complex. For the feelings stage, the teachers would consider and discuss what were their feelings prior, during and after the experience and the prompt questions would be designed to produce that information. In the case of this study, it would also include how the pupils felt at the time of the incident. The evaluation stage would appraise the incident in terms of what was good about it and what was not so good, as well as the contribution of others to those outcomes. The analysis stage involves making sense of the whole situation by determining all possible factors that could have contributed to the incident. In the conclusion stage some of the prompt questions are: What else could you have done, and What would be the ways to address such a situation? This reflective process is a learning process at the same time. Therefore, teachers are expected to learn from the incident and know what to do if they were faced with the negative incident in the future; how they would improve the situation and make it better for the pupils. The final stage is an action plan of how to effectively cope with such a situation in the future. The prompt question here could be: If the incident arose again what would you do? Each stage is connected and feeds into the next step.

When juxtaposing Gibbs' and Kolb's models, one can observe the similarities and differences between them. For example, both agree that learning from experience occurs in stages or cycles. However, Bassot (2013:58) points out that "Gibbs' emphasis on feeling takes reflection to a higher level and can be seen as a key milestone from RP to critically RP". One of the strengths of Gibbs' reflective model in this study is that it encourages self-development through the identification of strengths and weaknesses, and then acting on them. Gibbs' (1988) Reflective Cycle has been adopted as an RP tool in this study, and which guided the teachers in the writing up of their journals. Despite the popularity of Gibbs' Reflective Model, it has been criticised for being un-reflexive, not enabling critical thinking, not allowing the practitioner to move beyond practice and explore values (Finlay, 2008; Middleton, 2017). Furthermore, Rolfe, Jasper and Freshwater (2011) explain that there is a missing logical link between the 'Action Plan' and the 'Description' stage in Gibbs' Reflective Cycle Model. Therefore, this has allowed calls to be made for broader and more critically reflective models. However, Gibbs' model has been cited by various authors in connection with RP in education (e.g. Paterson and

Chapman, 2013; Chen et al., 2018; Ahmed, 2020). Recently, Ahmed, (2020) used Gibbs' model with 55 Qatari female undergraduate pupils to explore their perspective of reflective journaling in an English writing course. The pupils reported benefits and challenges of using reflective journals.

3.4.9 Reflective Journal Writing and Reflection

> *Every teacher needs to improve, not because they are not good enough, but because they can be even better.*
>
> (Dylan Wiliam, as cited by Tomsett, 2015:23)

The above quote insinuates that teacher should continually learn from their practices if they want to keep improving themselves and their pupils learning outcomes. One of the many statements put forward by Schön (1983, 1987) is that practitioners such as teachers should be able to critically reflect on their experiences and learn something from them. Several RP strategies have been identified in literature. For example, Mathew and Peechattu (2017) identify seven reflection strategies as follows: reflective journal, collaborative learning, recording lessons, teacher educator's feedback, peer observation, student feedback and action research. As indicated above, one of the many ways of recording reflection is to make use of reflective journals. One of the strong points of a journal is that it allows the learner to capture and foster reflection (Taylor, 2017). Greenall and Sen (2014) acknowledge that reflective writing in the form of journals is by far the most common form of reflection seen in the literature. Taylor (2017) explains that the journal is a more reliable way of capturing thoughts, feelings, and actions in real-time. In order to document their MKT development during the intervention phase of this study, the participant teachers were asked to keep a reflective journal (see Section 5.6.2). Casanave (2013:8) explains that a journal is considered to be reflective if it: "(1) engages the writer's feelings, emotions, interests, or curiosities; (2) connects the writer with something (e.g. with another aspect of the self, with another idea, with another person, with other experiences and subject matter); and (3) helps the writer develop the awareness needed to understand the self, an experience, an idea, or an event in expanded ways". Lai and Calandra (2010:422) agree that the reflective journal has so far been the most widely used RP tool in teacher education, with the inherent ability to develop "teachers' reflective thinking habits and skills". Sartain (2015) sees it as an important tool for transformative learning. Furthermore, Khanjani et al. (2018) explain that journal writing is a vital tool for the promotion of reflection. Additionally, Handscomb and Cockburn (2013:153) affirm a "teaching journal can become a powerful part of a teacher's continuing PD. It can provide a space for reflection". These authors confirm the usefulness of reflective journals.

By using the reflective journal as a learning tool for teachers and a reflective tool for data collection, the researcher is hoping that such an act will inculcate a culture of continuous improvement in teachers' MKT. Arguably, journaling has its own limitations. Firstly, it is quite evident that not all learners have the innate ability to express their inner thoughts in writing. Secondly, some learners will see the journal as invading their privacy (Chirema, 2007). Several studies have used journaling to capture the reflection of practitioners. Recently, Russo (2019) used reflective journals as part of his doctoral work to record his reflections and observations of eighty-four lessons on teaching mathematics intensively with challenging tasks. The significance of Russo's findings for this research is that it supports the broad acknowledgement of reflection and RP as being able to strengthen teachers' professional development and their daily practices.

3.4.10 Reflective Practice as a Knowledge Source

Scholars have identified several sources from which PCK as a component of MKT can be developed. Shulman and Shulman (2004) argue that crucial to teachers' knowledge and development, PCK development can most effectively happen through professional reflection on the part of the teachers. Many educational researchers (e.g. Dewey, 1933; Schön, 1987; Killion and Todnem, 1991; Postholm, 2008; Zahid and Khanam, 2019) are in agreement that reflection is one of the most important variables in teacher training, and to obtain teacher knowledge. Matt and Zakaria (2010) contest that reflecting is one of the ways of translating teachers' knowledge into action. Ma's (1999) findings indicate that the Chinese teachers had more in-depth mathematical knowledge, partly due to reflecting on their instructional practices. Yet, within the PCK literature, little is known about how primary mathematics teachers use RP as a foundation tool to further develop their MKT and self-efficacy beliefs.

3.4.11 Studies on Reflective Practice and Teacher Development

Recent literature reveals a handful of studies on the impact of RP on teachers' practices and development. Mathew and Peechattu (2017) conducted a qualitative study to explore the effectiveness of RP in the development of student teachers. Mathew et al. (ibid) conducted the study with a sample of thirteen students enrolled on a two-year B.Ed. programme in India, who had mathematics as one of their options. The study used questionnaires and reflective journals to collect data from the participants. In that study, the authors sought to examine how the teacher educator provides opportunities for the teachers to develop their RP skills during practicum. The authors concluded that "teachers can deal with the needs and different issues of the learners and demands of time if they reflect on their daily teaching and learning activities for their professional growth" (ibid:130).

Using an intervention study within an action research, Zahid and Khanam (2019) conducted a study in Pakistan to examine the effect of RP on the performance of prospective teachers at a women's university teacher-education programme. The findings revealed that the training provided to the teachers improved their skills and performance as they revised and modified their teaching approach through RP. In another study at a university in England, Walshe and Driver (2019) explored the support of video in the self-reflections of four student teachers. Among other things, the course content sought to develop CK and PCK of the students. The purpose of the study was to explore how the use of 360-degree video can support the reflections of student teachers. Among the main findings of the study, it was revealed that the use of video to support their self-reflections, developed in them "a more nuanced understanding of microteaching practice", as well as supporting their self-efficacy towards teaching (ibid:97). The researchers concluded that such application of video contributes to a more active and student-centred approach to teacher education. While Walshe and Driver's study focused on the use of video to support and enhance the reflection of teachers, this research uses a mnemonic strategy to support their reflections (see Section 5.7).

3.4.12 Studies on Reflective Practice and MKT Enhancement

Literature reveals three main areas of research which are drawing the attention of researchers with regards to the knowledge required for effective mathematics teaching. These areas are, firstly, how MKT can be measured (e.g. Hill, Ball and Shilling, 2004). Secondly, which area of teachers' knowledge supports pupils' achievement (e.g. Ma, 1999; Hill, Rowan and Ball, 2005; Baumert et al., 2010). Thirdly, how the level of MKT can be enhanced (e.g. Bell, Wilson and Higgins, 2010; Steele, Hitten and Smith, 2013; Nolan et al., 2015). Enhancing the MKT of primary teachers is the focus of this thesis. Prior intervention and observation studies have investigated the relationship between MKT and instructional practice (e.g. Baumert et al., 2010; Tirosh et al., 2011) as well as PCK and pupils' learning outcomes (e.g. Griffin et al., 2009; Baumert et al., 2010), without paying attention to the way primary teachers use RP to enhance their MKT. How it leads to high-quality mathematics instruction and better performance of teachers is inconclusive.

Literature reveals that there are many methods by which teachers' MKT can be enhanced. To name a few, they include school-based PD workshops, lesson study, classroom observation of colleagues, action research and being a reflective practitioner. Other methods include instructional explanations, which was used by Kinach (2002) to enhance the conceptual knowledge of secondary mathematics teachers. The result of Kinach's study showed that teachers had deepened their relational knowledge of secondary mathematics. Similarly, in another study, Chapman (2005) used a reflective-inquiry approach to enhance the problem-solving knowledge of twenty-eight pre-service secondary mathematics teachers. The main finding showed the teachers were able to construct meaningful knowledge about problem solving. The review of relevant literature shows that a few studies have been conducted with the aim of enhancing predominantly the mathematical knowledge of primary teachers. However, there is little research focusing on the enhancing of MKT and self-efficacy which is the focus of this study.

Several studies have found an association between general reflection of teachers on their mathematics teaching and change in their MKT (see Section 3.2.6). However, Hodgen and Johnson (2004) found reflection on practice that changed classroom instruction to be sporadic. McDuffie, (2004) conducted a study to examine the role of RP on the PCK of two primary pre-service mathematics teachers' practice in solving identified classroom problems. The study focused on how the teachers taught and used their PCK in their practices. The findings indicate that limitation of their PCK and lack of confidence hindered their reflecting ability while in the act of teaching; and they were more likely to reflect on their practices outside the act of teaching. The findings suggest that lack of PCK can hinder one's ability to reflect. However, that study focused specifically only on the PCK of pre-service teachers.

Chamberlin (2009) conducted a qualitative study to examine the impact of reflection on learning experiences during mathematics professional development of sixteen middle-school teachers. Analysis of written reflections and field-notes data revealed that teachers' reflections were more affiliated with teaching for understanding. Chamberlin made a recommendation for further research on how reflection leads to changes in teachers' classrooms. Chamberlin's recommendation is in line with Clara's (2015) remarks that the process by which reflection works is still unknown. Underpinned by a constructivist perspective, Turner (2012) conducted a longitudinal study of beginning elementary school teachers in England to investigate development in their MKT. The methods used were semi-structured interviews, focus group discussion, reflective interviews, and lesson observations. Turner used the knowledge quartet framework (Rowland et al., 2009) to help the participants focus their reflection in order to promote development in their MKT. Findings of the study indicated support for the development of MKT, although Turner emphasises that such findings do not indicate that simply reflecting on practice would bring changes to MKT. Turner used a number of methods and resources with the teachers, based on theories like social constructivism. In a relevant study, Van den Kieboom (2013) examined the types of MKT in the reflections of twenty-four pre-service teachers on the teaching of fractions to groups of elementary school pupils in the USA. Reflective journals were used to collect data from the participants. The journals were analysed for the following sub-domains of MKT: (a) Common Content Knowledge (CCK),

(b) Specialised Content Knowledge (SCK), (c) Knowledge of Content and Teaching (KCT), and (d) Knowledge of Content and Students (KCS). The findings of the study revealed that not only an interesting level of MKT was present in their reflections, but the MKT supported the analytic quality of reflection, thus allowing the teachers to produce more productive reflections. Van den Kieboom (ibid) also reported a marked difference in the quality of reflection of the pre-service teachers. A more relevant study on secondary teachers' reflection and MKT growth was conducted by Bargiband et al. (2016) in the USA. The study wanted to answer the following research questions:

(1) In what way do reflections on mathematical tasks affect the growth of MKT in secondary mathematics teachers?

(2) Do the type and quality of the reflections have an effect on what kind of growth (SMK or PCK) the teachers experience?

The ongoing mixed-methods intervention study collected data from teachers' reflections, teaching scenarios and pre and post-tests. The preliminary findings indicated that reflecting on mathematical tasks by the teachers led to positive growth in their MKT. However, the study was still conducted with secondary teachers; and it is argued that elementary teachers differ in their lesson preparation to that of secondary teachers (Speer, Hill and Howell, 2014). Also, Bargiband et al. (ibid) broadly discussed PCK and SMK, which are the two major domains of MKT, but fell short off breaking down those two domains into further sub-domains (e.g. KCS, KCT, CCK, SCK, KC and HCK). This would have made their study more comprehensive. In a study at a university in Ireland, Leavy and Hourigan (2016) used lesson study within collective case study, to support knowledge development of twenty-five pre-service mathematics teachers in their early number PCK sub-sub-domains, notably KCS and KCT which includes planning, teaching, reflection, and discussion. The teachers were instructed to reflect on their instructional teaching cycles of the lesson study. The findings indicated important growth in their MKT sub-domains. However, Leavy and Hourigan's (2016) study focused only on two MKT sub-domains, and RP was not the main focus of their study. The study was conducted with pre-service teachers rather than beginning in-service teachers. Although attention was dedicated to KCS and KCT, there was no discussion of how reflection impacted on those two MKT sub-domains. Leavy and Hourigan's (2016) study could have been a continuation of Bargiband et al.'s (2016) work. However, they focused on only one major domain of MKT which is PCK, and then addressed only two of its sub-domains (e.g. KCS and KCT). In a more recent study in Ireland, Leavy and Hourigan (2018a) used the lesson-study approach to examine the development of twenty-five prospective primary teachers' SCK as they developed, taught and reflected on their mathematics lessons on early number concept. The lesson study contains an ongoing cycle of lesson planning, teaching and reflections by a team of teachers; and promotes reflection practice (Lewis, Perry, and Murata, 2006). The findings of the study revealed that lesson study promoted the SCK of the teachers in two main ways. Firstly, the teachers were able to identify the sources and nature of the pupils' mathematical errors. Secondly, it raised the awareness of the complex relationships between number concepts that contribute to early number understanding. Both studies by Leavy and Hourigan (2016, 2018a) were embedded within lesson study design and revealed that reflecting on classroom teaching positively affected teachers' MKT. Taken together, these reported studies (e.g. Van den Kieboom, 2013; Bargiband et al., 2016; Leavy and Hourigan, 2016, 2018a) point to the importance of RP as an agent of change, and tend to provide a promising picture of its success in enhancing MKT. However, this thesis still argues that the field of mathematics education lacks detailed understanding of how primary school mathematics teachers use RP to develop their MKT. This provides both the need and catalyst to investigate how, through RP, primary mathematics teachers make changes to their MKT components when teaching, in order to improve the performance of pupils in mathematics. Therefore, as its purpose, the research investigated how RP impacts on the MKT and self-efficacy of primary teachers.

3.4.13 Teacher Self-efficacy

This study investigates the extent that RP impacts on the self-efficacy beliefs of the teachers. Teacher self-efficacy can be described as teachers' confidence to promote learning in pupils despite difficult conditions (Klassen and and Tze, 2014; Künsting, Neuber and Lipowsky, 2016). Charalambous et al. (2008:126) define teacher self-efficacy as "a teachers' sense of ability to organise and execute teaching that promotes learning". Recently, in a study by Bray (2011), it was noted that teachers not only draw on their MKT, but also on their belief systems. In the words of Jeon (2018:421), low teacher efficacy level is considered to be a significant predictor of teacher attrition and burnout among both experienced and novice teachers. Teacher self-efficacy belief has been linked to students' achievement. Khan (2012) found a significant relationship between teachers' self-efficacy and achievement in mathematics. In a study with fifty-eight primary school teachers and 1244 pupils in Taiwan, Chang (2015) found that teachers' self-efficacy had significant correlation with pupils' mathematical scores. Mathematical knowledge development of teachers also depends on their teaching confidence or self-efficacy to effectively teach mathematics. Teacher self-efficacy has been associated with the seminal social cognitive theory of Bandura (1997:3), who defines self-efficacy as "beliefs in one's capabilities to organise and execute the courses of action required to produce given attainments". Educationalists explain that teacher efficacy is connected to pupils' high performance (e.g. Krpan, 2018). Bandura (1997) further elaborates that self-efficacy is critical to the learning process.

Bandura (1997) identified four sources of self-efficacy belief, which are: mastery experiences, vicarious experiences, verbal persuasions and physiological responses. Mastery experience is the idea that a high sense of self-efficacy can be built from past successes. In the case of teachers, their self-efficacy belief is influenced by past experiences which either increase or decrease their sense of capability and self-efficacy.

However, past failures lower one's sense of self–efficacy. Vicarious experience is to perceive one's ability to perform a task through the successes or failures of others. That is, inexperienced teachers can enhance their own self-efficacy by observing others doing similar tasks and using them as models, to compare their capabilities. Verbal persuasion is the verbal encouragement the teachers would get from others, such as colleagues. Getting encouragement from colleagues would normally help clear self-doubts. Lastly, physiological response is about the influence of anxiety, emotions and stress levels on self-efficacy. These physical and mental states determine if someone would be able to deal with challenges (Bandura, 1977; Tai et al., 2012). Newton et al. (2012) found a positive relationship between content knowledge and self-efficacy of pre-service teachers in the USA. Studies such as Yeh (2006), Choy et al. (2017), and Walsh and Driver (2019) showed that reflective thinking led to self-efficacy. However, few to no empirical studies exist addressing the extent to which RP impacts on MKT self-efficacy of primary school teachers specifically. In this study, the self-efficacy beliefs of primary teachers are linked to their level of confidence in MKT. The research assumes that self-efficacy can be developed. The objective is to partly investigate to what extent RP changes teachers' MKT self-efficacy and mathematics self-efficacy (MTSE) beliefs in relation to their MKT word problem solving strategies. MTSE in the educational context of this study is defined as teachers' belief in their perceived ability to successfully complete an educational teaching task (Bandura, 1997).

3.5 Arithmetic Word Problem Solving

Word problem solving continues to be an issue for pupils, and in some cases for teachers as well (Morin et al., 2017; Mingke and Alegre, 2019). Despite the challenges that word problems present to several primary school pupils, they play a crucial role in the mathematical world of a child (Kurshumlia and Vula, 2013). This is because arithmetic word problems start linking school mathematics to real-life problem solving (Wong and Ho, 2017). Solving mathematical problems when presented as an arithmetic word problem rather than in numeric format is one of the areas in the primary school curriculum in which pupils have great difficulty (Cummins et al., 1988; MOE, 2014a; Wong and Ho, 2017). A recent study by Wong and Ho (2017) revealed that pupils' difficulty in solving arithmetic word problems had to do more with their inability to write down number sentences than with computation. In arithmetic word problem solving, the pupil is expected to derive the number sentence from the word problem. This would suggest there are other factors inhibiting pupils other than methodical skills when it comes to arithmetic word problems. Jitendra et al. (2015) explicate that mathematical word problem solving involves several cognitive processes such as memory and language, as well as metacognitive processes which include self-questioning and self-monitoring. Literature also reveals that pupils with learning difficulties would also tend to find arithmetic word problem solving difficult (e.g. Osman et al., 2018). Before attempting to solve word problems, pupils would need to comprehend the text and context of the problem by reading the text. Therefore, those pupils with a language barrier would find it difficult to understand the text. The comprehension demands in word problems combine with pupils' other learning difficulties to make the solving of word problems a challenging task (Krawec et al., 2013). Also, Cummins et al. (1988) and Adu and Olaoye (2014) explain that most of the difficulties that pupils encounter with word problems are linked to having to comprehend abstract or ambiguous language. Cummins et al. (1988:405) tested their hypothesis, and the findings revealed that what was classified as solution 'errors' were, in fact, correct solutions to miscomprehended problems. In addition, the limitation of teachers' skills in handling word problems worsens the pupils' situation; and so, this is an area that teachers need to develop and implement in order to teach effectively (Hertzog and O'Rode 2011). Avcu and Avcu (2016), in their study of ninety-three, pre-service elementary mathematics teachers, found they had the capability to use problem-solving strategies but were limited in the use of different strategies.

3.5.1 Mnemonics Strategies and Word Problem Solving

The teaching and learning of word problem solving strategies can be a challenge for both teachers and pupils. Various strategies have been used to help pupils solve arithmetic word problems. Early research was keen to address the cognitive processes and mental representations involved in arithmetic word problems (Lewis and Mayer, 1987; Wong and Ho, 2017). Mayer and Hegarty (1996, cited in Wong and Ho, 2017:520) posit that arithmetic word problem processes can be organised into these four stages: translation, integration, planning and execution. In the translation stage the pupil constructs a mental image of the problem; then for the integration stage the pupil gathers the different types of information given and starts making sense out of them. Next, the pupil prepares a plan of execution, and then executes the plan. Most of the word problem solving strategies have been derived from a similar model described by Mayer and Hegarty (ibid), comprising problem comprehension and the solution stages (Hickendorff, 2013; Gunbas, 2015). For a long period of time researchers and educators have been using mnemonic strategies to address various teaching and learning problems, including learning disabilities (LD), memory enhancement, remediating mathematical skill deficits, and solving word problems

(Machida and Carlson, 1984; Watanabe, 1991; Scruggs and Mastropieri, 1991; Wood and Frank, 2000; Maccini and Ruhl, 2000; Maccini and Hughes, 2000; Bryant et al., 2003; Terrill, Scruggs, and Mastropieri, 2004; Scruggs et al., 2010; Everett et al., 2014). Jurowski et al. (2016:4) define mnemonics as “as learning strategies which can often enhance the learning process and later the recall of information”. Mastropieri and Scruggs (1998) explain that it is a beneficial strategy which allow students to code and recall information to improve learning outcome. Mnemonic strategies gained saliency in helping pupils with LD to remember information when there are many concepts and much content to learn (Levin, 1993). One exemplary study was conducted by Scruggs and Mastropieri (1991) with nineteen mild LD pupils. The pupils were taught science using mnemonic instruction and more traditional instruction. The findings of the study revealed that mnemonic instruction contributed to a significant increase in the pupils’ initial content acquisition and higher delayed-recall scores compared to the more traditional instruction. The pupils showed preference for the mnemonic instruction over traditional instruction methods. However, researchers and educators have come to different conclusions, including whether mnemonics should be used at all in education (e.g. Fontana et al., 2007; Brigham et al., 2011; Kalder, 2012; Dunlosky et al., 2013; Dupree, 2016). For example, Kalder (2012) advocates the view that memorised mathematical mnemonics (e.g. BODMAS) may lead pupils to mistakes and mislead them to believe that mathematics is a set of formulas to be memorised, and its use should be abandoned. Dunlosky et al. (2013) have been critical of its use in the classrooms as a technique to improve pupils’ learning. On the other hand, proponents of mnemonics have been supportive of its use in education; and a number of researchers (e.g. Worthen and Hunt, 2011; Putnam, 2015; Lubin and Polloway, 2016) are in agreement that it is a type of memory-enhancing tool for learners. Relevant to this research is the linguistic class which Lubin and Polloway define as using pegword (Roediger,1980) and keyword (Atkinson, 1975) method to associate new concepts with familiar words in order to help the learner remember the items. Some of the commonly used mnemonic strategies in education are acronyms, acrostics, keywords, pegwords, and pictographs. However, in mathematics teaching, acronyms are more commonly used because pupils tend to find them more useful (McCabe et al., 2013; Lubin and Polloway, 2016); for example, BODMAS for (Bracket, Of, Division, Multiplication, Addition, and Subtraction) which guides the order of operation in mathematics; and SOHCAHTOA in trigonometry. A number of different mnemonic problem-solving strategies such as FAST DRAW (Mercer and Miller, 1992), TINS (Owen, 2003), RIDE (Mercer, Mercer, and Pullen, 2011) and STAR (Gagnon and Maccini, 2001) have been used to assist pupils in solving mathematical word problems (Hott et al., 2014). These mnemonic strategies use acronyms to represent steps which the pupils must follow. Recently, in a master’s study, Locke (2016) used RIDE mnemonic strategy to help pupils solve mathematical word problems. RIDE is an acronym representing: *Read* what this problem is asking you to do, *Identify* what information you have to solve this problem, *Describe* the operation, *Enter* the numbers and calculate (Locke, 2016). The pupils were taught word problem solving using the RIDE mnemonic strategy. The results of the study showed that all the pupils had an increase in their quiz score when RIDE mnemonic strategy was included in their mathematics instruction.

Furthermore, one of the arguments in favour of the use of mnemonics is that students struggle with mathematics not because they are unintelligent or unmotivated but, rather, that they lack the perceptual and associative processing tools that enable them to process numbers and mathematics (Berg, 2009). Mnemonics provide pupils with an internal mental model to represent and comprehend the problem (Lewis and Mayer, 1987; Gunbas, 2020). Many researchers agree that many pupils cannot solve mathematics word problems because of difficulties in the comprehension stage (e.g. Gunbas, 2015; Yenilmez and Yasa, 2007). Scruggs, and Mastropieri (1991) aver those mnemonic strategies impact positively on learning outcomes of students. More recently, Miller and Obara (2017:13) explain that if used wisely, "mathematical mnemonics can benefit students' performance and understanding".

Specific to word problem solving, Machida and Carlson (1984) experimented with verbal mnemonics in the recalling of mathematics computations and problem solving among a hundred Japanese 7th graders for ten weeks. Results of the study show significant differences, favouring the experimental group of students. In Maccini and Ruhl's (2000) study to determine the effects of the STAR mnemonic strategy on problem-solving skills of students with LD, they found that the students improved their ability to solve word problems containing subtraction of integers. Watanabe (1991) used an intervention study and the SIGNS (*Survey* question, *Identify* key words, *Graphically* draw problem, *Note* operation, *Solve* and check) mnemonic strategy to make students visually represent and solve mathematical word problems. Freeman-Green et al. (2015) investigated the effects of the SOLVE mnemonic problem-solving strategy on the mathematical problem-solving skills of secondary students with LD in the USA. Results of the study showed a functional relation between the SOLVE strategy and improved problem-solving performance for all participants. Also, Maccini and Hughes (2000) conducted a study on the effects of the STAR mnemonic problem-solving strategy on the problem-solving skills of six secondary school students with LD. The findings of their study indicated improvement in the problem-solving skills of the students. Cassel and Reid (1996) used mnemonic strategies to improve word problem solving skills of third and fourth-grade students with mild disabilities. The findings of the study indicated major improvement in the number of problems the students were able to solve.

Also, research shows that students with LD enjoy working with mnemonic strategies and develop more positive attitudes towards mathematics (e.g. Scruggs and Mastropieri, 1991). The visuality of some mnemonics make the problems more comprehensible to the students when the words are not helping them. More recently, Putnam (2015) explains that mnemonics can be a learning tool for both teachers and pupils in different educational contexts and its use has been well advocated by many mnemonists and researchers (e.g. Freeman-Green et al., 2015; Miller and Obara, 2017; Ni and Hassan, 2019; Drushlyak et al., 2021). Ni and Hassan (2019) and Boon et al. (2019) explain that the application of mnemonics techniques is very much needed and can help students remember many facts by improving their memory with little effort. The authors further argue that the failures to master mathematical knowledge are due to the use of inappropriate cognitive strategies by the students. Also, Ni and Hassan (ibid) state that when implementing the mnemonic strategy one basic principle that should be considered is the use of mental images. The use of mental images has been considered in this research (see section 5.7). Drushlyak et al. (2021:2) argue that due to cognitive overload when learning mathematics, the use of mnemonics is a way to improve new information for the students, and also "a methodological tool that will make students interested in mathematics." Also, the pragmatic reasons for advocating mnemonic strategies in this study derive from the fact that it has been well researched and shown to improve students learning (Levin, 1993); that is, it encourages problem solving, improves the students' mathematical ability, especially those students having difficulties with mathematics instruction (Boon et al., 2019). Additionally, Everett et al. (2014) argue that even if past mnemonic interventions have largely targeted students with LD, there is no empirical reason why it cannot benefit other at-risk students in mathematics; that is, students without disabilities who struggle with the learning of mathematics. For example, in an intervention study conducted by Test and Ellis (2005), a mnemonic strategy called LAP was used to address fractions deficit of six students. The findings of the study show improvements for five of six students' knowledge of the LAP mnemonic as well as in the percentage of fraction problems solved correctly. In this research, a mnemonic strategy called PIES (Heater et al., 2012) was used to help pupils solve word problems, that is, to help them detect and remember the different correct steps to arrive at an answer (Xin et al., 2011). PIES is an acronym mnemonic representing: Draw the *Picture*, pull out the *Information*, write down the *Equation*, and write the *Solution*. However, Scruggs and Mastropieri (1990) opine that acronym mnemonics are more effective when the first letter of a process spells out the step required by the pupil, which is not the case with PIES. Heater et al. (2012) explain that pupils have difficulties when problems are presented in word problem format. The

PIES strategy was successfully used to assist pupils in their science classes (e.g. Heater et al., 2012). Those same pupils later applied the same strategy to successfully solve their algebraic word problems. To date, very little research evidence has been found which addresses the effectiveness of the PIES mnemonic strategy in a real mathematics class.

3.6 Gaps in the Literature

Despite the variety and frequency of research in primary mathematics education, inconsistencies and disagreements exist about how RP can bring fruitful learning in teachers and change their practices (Leigh and Bailey, 2013; Collin, Karsenti, and Komis, 2013; Beauchamp, 2015). Moreover, Goos et al. (2008) note a lack of research on the MKT and development of practicing teachers over time. Somehow, only a few studies have explored how RP has led to change in teachers' MKT. Moreover, there is enough evidence to argue that the reported studies on teachers' MKT (see Section 3.4.12) have been narrow in scope, focusing on limited mathematical knowledge types, and not having RP as their main focus; except for Bargiband et al. (2016). Moreover, those authors did not verify whether the six types of knowledge for primary mathematics teaching were empirically discernible.

This present thesis seeks to address these gaps within the literature and extend on previous research literature by building on the works of Bargiband et al. (2016) and Leavy and Hourigan (2016, 2018a). This research carves its way into a focused area of MKT, and seeks to address gaps in methodology, knowledge, and theory. This study focuses both on the SMK and PCK domains of the MKT framework and investigates the extent to which they could be enhanced through RP. The contention for the research is that despite the extensive literature on MKT, and the recognition that a teacher's MKT has a crucial impact on pupils' learning, rarely are the reflections of primary teachers on their MKT explored. If the primary mathematics teachers have to develop their instructional knowledge in order to become expert teachers, then it needs to be known how teachers' MKT, being an important teaching construct, can be developed. The scarcity of such studies for SIDS makes this research particularly timely and significant and creates the necessity to explore such phenomena in the context of Seychelles where pupils are scoring very low in primary school mathematics.

How do teachers reflect on their MKT in order to bring changes in the learning outcomes of their pupils? What we do know is that there has been meagre work done in the described area. Most scholarly studies on MKT have largely been conducted with primary and secondary pre-service teachers (e.g. Isiksal and Cakiroglu, 2008; Watson and Nathan, 2010; Blömeke et al., 2011; Vale et al., 2011). In addition, how primary school teachers change their MKT and self-efficacy beliefs has never been studied in Seychelles. In addition, most research has utilised a qualitative methodology to investigate how the

MKT of primary teachers can be enhanced. However, this research takes a different methodological approach by integrating a quasi-experiment within an inductive qualitative design (e.g. Green et al., 2015), and employs a mixed methodology within an interpretive paradigm to explore the effects of RP on MKT and self-efficacy beliefs of primary teachers. It is more advantageous to apply such methodology as it is likely to have more validity and better explore the phenomena compared to previous studies.

3.7 Chapter Summary

The review examined the theoretical background of MKT from the ground-breaking work of Dewey (1933) and Schön (1983, 1987), Shulman (1986,1987) and Ball et al. (2008), all of which provide a theoretical background to the study. Shulman's (1986) seminal work on teachers' professional knowledge base has triggered an abundance of further studies in that area. One of the strong themes that can be captured from the various studies on MKT is that there is a distinctiveness to it for the work of teaching. This distinctiveness is being sought by researchers from different research perspectives. The literature review also revealed that very few studies have used intervention studies to examine the effects of RP on the MKT and self-efficacy of primary school teachers. MKT is seen as an important construct in the current literature on knowledge to teach mathematics in primary schools. Various scholars (e.g. Borko et al., 1992; Ma, 1999) are in agreement that teachers who lack mathematical knowledge are less likely to present instructional materials clearly and error-free to their pupils. The premise of the review is that the PD of teachers is a key factor in determining the quality of their teaching. The review has highlighted the need to enhance the MKT and self-efficacy of teachers with the aim of improving pupils' mathematical performance. Having considered all the relevant literature, this review suggests that RP has the potential to make fruitful changes to the MKT of teachers, and to enhance their self-efficacy beliefs. In particular, the chapter has provided an in-depth review of the effects of RP of teachers on the development of teachers' MKT; the argument being that using teachers' characteristics as a demarcation reference has not worked. However, since teaching is a 'learned profession', then the MKT of teachers can be nurtured. Teachers can learn from various sources, including reflection on their own practices through school-based developments. Amongst others, Gibbs' (1988) reflective cycle model has been examined and is seen as a tool which could help the teachers to structure their reflections and journal writing. The review identified various gaps in the literature of RP, MKT and self-efficacy beliefs of primary teachers. Firstly, prior studies have provided little information on the effects of RP on the MKT and mathematics self-efficacy beliefs of primary school teachers in SIDS. Secondly, there is a scarcity of literature on how RP influences MKT sub-domains. Thirdly, very little intervention research exists on how to enhance the MKT sub-domains of teachers through RP in SIDS contexts.

This research seeks to address these gaps within the literature. The next chapter discusses the conceptual and theoretical framework used in this research.

Chapter 4: Conceptual and Theoretical Frameworks

4.1 Introduction

This chapter presents the conceptual and theoretical frameworks underpinning this study. Mezirow's (1991) transformative learning theory (TLT) is used as the predominate theoretical approach to conjecture the process of teachers' transformation. The reason for using Mezirow's theory was because it informs the study, it uses reflection to critically challenge teachers' beliefs (Mezirow, 1991), and it provides a solid base to understand how the teachers reflect on their practices to become better practitioners. Other frameworks which could have been considered are those of Guskey (2002), Clarke and Hollingsworth (2002), and King (2014). The study is also placed within an interpretivist paradigm; and theoretically grounded and framed within the social-constructivist perspectives of adult learners.

The chapter is organised into four sections. After the introduction, Section 4.2 presents the conceptual framework. This is then followed by Section 4.3 with a presentation of the theoretical frameworks. Section 4.4 summarises the chapter.

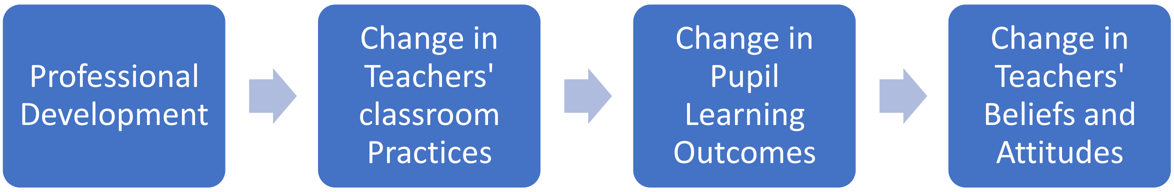
4.2 The Conceptual Framework

To study the effectiveness of RP on teachers' MKT, this thesis needs a conceptual framework that will explain how RP works to influence change in teachers' MKT knowledge, and ultimately improves pupils' learning outcomes. The study also needs a framework built on research-based principles, justified by theoretical literature, in order to be used as a point of reference and useful structure to interpret the empirical findings. The main aim of most PD programmes is to change the classroom practice of teachers, which would ultimately result in the change of learning outcomes of pupils. Savin-Baden and Major (2013) opine that a research report without a conceptual framework would lack scholarship. A variety of widely used models conceptualise the learning process of teachers (e.g. Guskey, 2002; Desimone, 2009; Clarke and Hollingsworth, 2002) and contain features of all the three aforementioned models relevant to this research.

Desimone's (2009) professional development model was adapted and used as a conceptual framework to frame this intervention study. One important consideration for choosing Desimone's framework is that it features important properties of effective professional development which also relate to effective teaching of mathematics such as: content focus, active learning, fostering coherence, and collective participants and duration. Desimone's framework is widely used to conceptualise studies on professional development of teachers (e.g. Whitworth and Chiu, 2015; Lindvall, 2016; Desimone and

Pak, 2017; Park et al., 2018). Other considered frameworks were the linear path model of Guskey (2002); the interconnected model of Clarke and Hollingsworth (2002); and King (2014). Guskey's (2002) model is about professional development and teacher change and focuses on how the changes in beliefs and attitudes of teachers happen.

Figure 4.1: Guskey's (2002:383) Model of Teacher Change



In contrast, Desimone (2009:183) suggests her linear model should be used in "studies designed to describe trends, associations, or impacts of professional learning on knowledge instruction, and pupil achievement". On the other hand, Clarke and Hollingsworth (2002) built their model on the work of Guskey (2002) and proposed that teacher change can occur in a non-linear fashion through reflection and enactment. Firstly, the appropriateness of Desimone's (2009) framework is that it is made up of typical, high-quality professional learning constructs for teachers, which improve teaching and thus pupils' achievement, and which are based on positive findings from empirical studies (Evans, 2008; Kang et al., 2013; Hill et al., 2013; Darling-Hammond et al., 2017; Kutaka et al., 2017). Secondly, apart from being widely cited (see Table 4.1), in Desimone's own words, her model is more appropriate in supporting studies on the "impacts of professional learning on knowledge instruction" (Desimone, 2009:183).

Table 4.1: Citation popularity of PD Models

Source: Google Scholar April 2020

Model	Citations
Guskey (2002)	3541
Clarke and Hollingsworth (2002)	2149
Desimone (2009)	3637

Moreover, various international studies and theoretical literature have claimed that Desimone's framework is solid and effective for evaluating the effects of professional development (e.g. Kang et al., 2013; Rodriguez et al., 2020). Based on the features of effective PD discussed in the literature review (Section 3.3.6), specifically those discussed by Desimone (2009), a conceptual framework for the study is laid out.

The conceptual framework gains saliency from Borko (2004:6) who writes that:

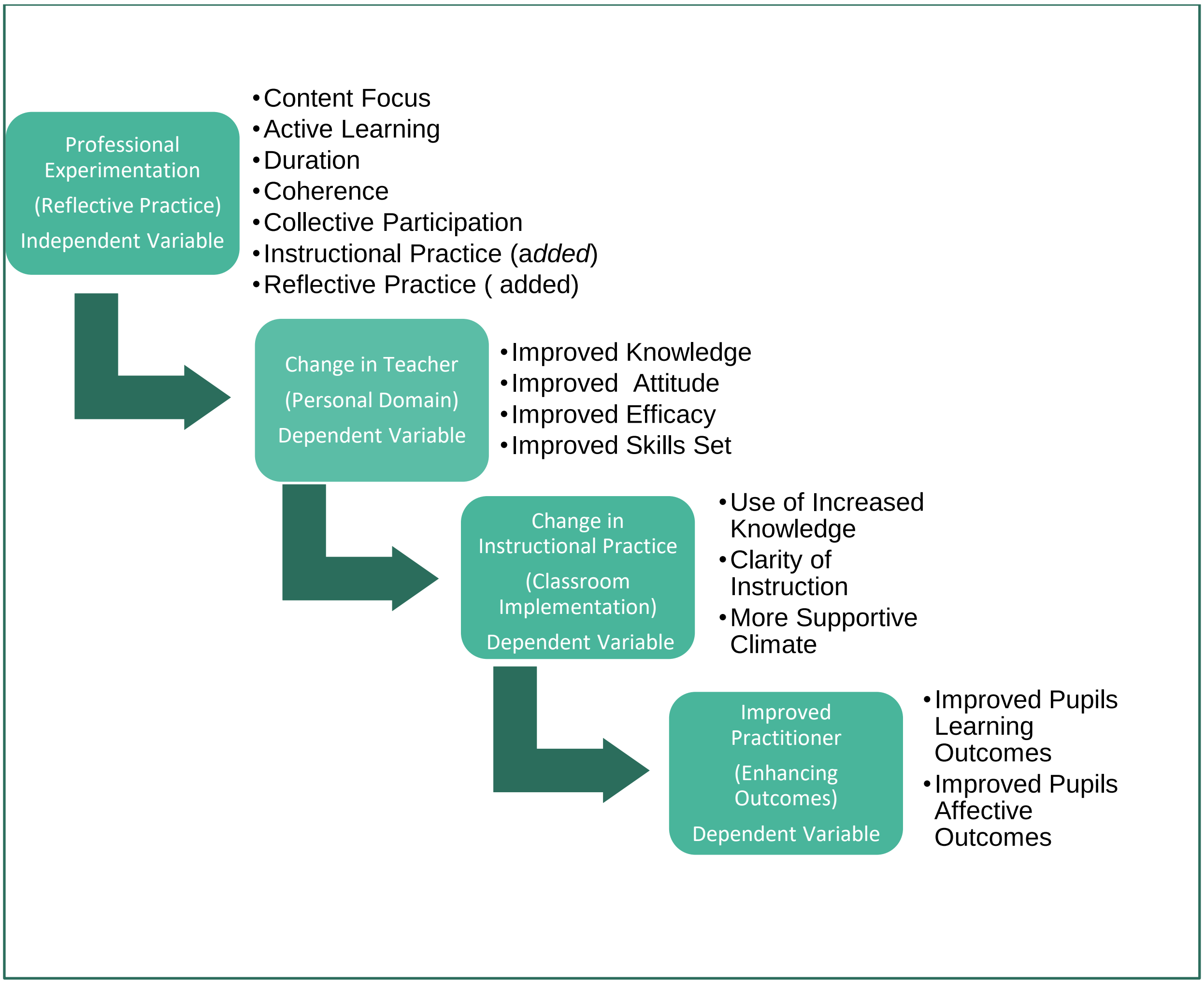
> *For teachers, learning occurs in many different aspects of practice, including their classrooms, their school communities, and professional development courses or workshops.*

Desimone (2009) provides a framework for how an effective PD impacts on teachers and pupils. The framework also forms the focus and rationale for designing the PD activities and training sessions with teachers in this study. In addition, elements of the conceptual framework from Figure 4.1, (e.g. professional development, teacher change, change in instructional practice) provides a framework for analysis. The framework also enables a theory of change in teachers' practices to be developed, thus leading to the hypotheses in this study of how the right conditions of professional development programmes could lead to change in teachers' MKT and their self-efficacy beliefs. When adopting the framework for the study, it is assumed that teachers' knowledge, efficacy, attitudes, and instructional practice can be gradually shaped over time (Salīte et al., 2016) under the influence of specific events and contexts; as well as teachers' learning by reflecting on their own practices. The purpose of the conceptual framework is to give a broader understanding, and a more integrated way of approaching events in the study and the research problems. Miles et al. (2014:20) posit that conceptual framework can be explained either graphically or in a narrative form and represent the "researchers' map of territory being investigated". The four-steps conceptual linear principles of Desimone's (2009, 2011) framework is as follows: Professional experimentation, Change in teacher, Change in instructional practice, Improved practitioner, as depicted in Figure 4.1. The conceptual framework depicts a clear causal chain link or interwoven relationship between the various domains of the framework. In this framework, the teachers immerse themselves in an effective professional development programme. Such an immersion experience can potentially lead to change in teachers' knowledge, skills, attitudes, and efficacy. Then, these potential teacher changes lead to improvement in teacher instructional practice, leading to increase in pupils' learning outcomes across subjects (Borko, 2004; Jukes et al., 2017; Darling-Hammond et al., 2017). This conceptual framework is used to guide the development of the methodology of this study. However, it is worth noting that even if there was a strong positive correlation between teachers' professional development experience and positive learning outcomes of pupils, it would be hard to claim causation (Guskey and Sparks, 1996; Guskey, 2002; King, 2014). Moreover, Avalos (2011) argues that even if a PD framework has evidence of positive impact, it might still not be relevant to all teachers;

plus, the fact that there is the constant necessity to study and keep on experimenting when working with teachers' PD programmes. This is because the relationship in the chain is highly complex. Desimone's model is still being utilised, revised, and applied to different contexts. For example, Dunst (2015) built on Desimone's (2009) model and applied it to in-service professional development in early childhood teaching. The four components of the study's conceptual framework are as follows:

Figure 4.2: Conceptual Framework for Studying the Effects of PD on Teachers

Adapted from Desimone's (2009) PD model.



4.2.1 Professional Experimentation

Scholars such as Desimone (2009) and Livy et al. (2016) explain that what teachers experience in terms of developmental activities during the PD is critical to their professional development. In this study, the teachers' immersion experience (Loucks-Horsley et al., 2010) consists of their interaction with the PIES mnemonic problem-solving strategy, the reflective model, and other support materials which are critical in the building of their mathematical knowledge for teaching. Desimone (2009) and Desimone and Garet (2015) identify five features or important characteristics of effective professional development, which are content focus, active learning, coherence, duration, and collective participation. However, the consensus on the five features has been derived from small-scale studies (Goldsmith et al., 2014; Kennedy, 2016; Lindvall and Ryve, 2019). These features have been identified in literature from both theoretical and empirical findings. The features are as follows.

Content Focus

One of the developmental activities which teachers should experience during their PD session is a focus on their subject matter content, and how their pupils learn that content (Darling-Hammond, 2013). The curriculum area of focus in this study is arithmetic word problem solving. Even if research on teachers' knowledge for teaching has given mixed results with regards to the importance of subject matter knowledge (SMK), the mastery of teachers' subject content knowledge is still an important part of teacher education. For example, in a study conducted by Metzler and Woessman (2012) in Peru, they found that an increase of one standard deviation in teachers' subject-matter knowledge increased pupils' learning outcomes in mathematics and reading by 0.1 standard deviation. Despite its importance for effective teaching, poor content knowledge of mathematics teachers has been reported by various studies; for example, Livy and Vale (2011) and Livy and Herbert (2013) in their work with pre-service primary teachers in Australia regarding their thinking, strategies, common errors, and misconceptions in their responses.

Active Learning

In addition to being content focused, the teacher should experience active learning. For active learning, Desimone (2011:69) writes that:

> *Teachers should have opportunities to get involved, such as observing and receiving feedback, analysing student work, or making presentations, as opposed to passively sitting through lectures.*

Prince (2004:23) defines active learning as "any instructional method that engages pupils in the learning process". Such engagement is defined by Lowe (2013:328) as follows:

> *Active learning can also be defined as purposeful interaction with ideas, concepts and phenomena and can involve reading, writing, listening, talking or working with tools equipment and materials, such as paint, wood, chemicals, etc.*

From the above definitions, active learning can be taken as a type of experiential learning where the learner or teacher designs new interactive learning activities for their pupils, trying them out and learning through those activities as well. The participants in the study are actively involved in teaching and addressing their own pedagogical issues with problem solving. Active learning can benefit both teachers and pupils. In the case of teachers, they would spend more quality time with a group of pupils, which would, arguably, enable high-quality interaction to take place.

Duration

Teachers should have enough time to learn, reflect and implement the PD activities. Such time enables the teachers to have enough practice of the relevant learning activities in order to develop the necessary, knowledge, skills, and attitudes for implementation. Researchers generally agree that professional development should be spread over a year; with a contact time of at least twenty hours (Yoon et al., 2007; Johnson and Fargo, 2014; Desimone and Garet, 2015). For example, in their 2007 study, Yoon et al. identified nine intervention studies which had an average of forty-nine hours of PD per year. In this study, the teachers participated for a duration of ten weeks of professional development; that is the amount of time over which it occurred (Desimone, 2009). Research has shown that PD of longer duration is generally more effective in bringing change to teacher practices (e.g. Whitworth and Chiu, 2015).

Coherence

For the PD to be effective there should be a coherence and consistency between what the subject area PD is providing and what other professional development programmes the school at large is currently proposing and trying to address (Desimone, 2009). The design of the intervention in this study is in accordance with mathematics national curriculum visions of the schools in Seychelles.

Collective Participation

Lastly, Desimone (2009) and Desimone and Garet (2015) suggest that effective PD should occur within an interactive Professional Learning Community (PLC) involving teachers of the same teaching grade. PLC would enable teachers to come together with a concerted effort to improve themselves and ultimately improve their pupils' achievements. It was anticipated that the PD session would ultimately create the notion of a community of practice among the teachers, who would work collaboratively and potentially change the school culture, if necessary, in order to improve their instructional practices.

4.2.2 Results of Experiencing High-Quality PD

After experiencing high-quality PD, changes are expected in the teachers' knowledge, in their practices, and in an increase in the pupils' learning. Gamlem (2015) posits that supporting the classroom changes of teachers should start with changes to their current belief system. Educationists have agreed the belief system of a teacher affects the way they go about their teaching. Changes in teachers should be reflected in their knowledge, attitude, strength of their self-efficacy beliefs and skills set, as well as in the content of their journals (see Figure 4.1). Bounded in time, RP is expected to change the teachers' beliefs, knowledge, skills, and mathematical self- efficacy. Various studies in both PCK and MKT (e.g. Baumert et al., 2010; Cueto et al., 2017) have clearly demonstrated that RP positively impacts these two types of knowledge base. The conceptual framework hypothesised that reflected PD would influence the instructional practice of the teachers, which in turn would predict pupils' learning outcomes (e.g. Wallace, 2009; Roth et al., 2011). Generally, there would be emerging signs in the classroom that could signal if there were significant quality changes in the practice of the teacher. Some of the signs would be the use of increased knowledge, clarity of Instruction, cognitive activation, a more supportive classroom climate, more pupil engagement, and better classroom management (Rakoczy et al., 2007; Lipowsky et al., 2009). Cognitive activation is when the teacher works with their pupils so that they can engage in higher-level thinking to promote conceptual understanding. In a study conducted by Lipowsky et al. (2009), a supportive climate, good classroom management and cognitive activation were found to have a positive effect on the mathematics achievement of pupils. Good classroom management is also seen as a feature of effective mathematics instruction. Effective classroom management provides the pupils with quality time for them to cognitively engage with the learning materials.

Some scholars (e.g. Guskey, 2002) explain that most teachers define their classroom success in terms of the learning outcomes of their pupils. A number of studies (e.g. Tatto et al., 2012; Allen et al., 2015; Blömeke, et al., 2016) have linked teacher quality to learning outcomes of pupils. If a teacher PD programme is claimed to be effective, then its result should also be seen and measured both in terms of learning and affective outcomes of the teacher. Learning outcome could entail improvement on the raw assessment scores of the teacher, and affective outcomes could be in terms of the teacher being more motivated to learn and teach the subject, a change of attitude, and showing more appreciation of what they are teaching.

4.3 The Theoretical Frameworks

While the above conceptual framework depicts a causal link in an effective professional development programme for teachers, a theory was also needed to describe the process of professional development of the teachers, which is compatible to adult learning. Anfara and Mertz (2006:17) state that "a useful theory is one that tells an enlightening story about some phenomenon. It is a story that gives you new insights and broadens your understanding of the phenomenon". Basit (2010:36), also explains that theory could be "about the relationship between specific phenomena in a social setting". The theoretical basis for this research recognises teachers' knowledge development and teacher learning acts as a complex system (Goos and Geiger, 2010; Opfer and Pedder, 2011), and limited conceptualisation occurs if guided by a single theoretical framework. Goos et al., (ibid) acknowledge that the complexity of teacher learning makes mathematics researchers use a variety of theories. Silverman and Thompson (2008) explain that there is no commonly accepted theoretical framework for conducting research in mathematics education. Moreover, extant literature does not provide a suitable framework to analyse teachers' subject knowledge in a specific mathematical area, and neither does it provide one which incorporates reflection practice and MKT development. Thus, it is preferable to develop a suitable framework to guide this study (Speer et al., 2014). Fortunately, many theories of adult knowledge construction and transformation inform such a perspective. The study of teachers enhancing their mathematical knowledge can be researched from different perspectives with the lens of an amalgamation of frameworks to include, among others, constructivism, socio-cultural theories (Vygotsky, 1978), cognitive theory, social justice theory, education productivity theory (EPT) (Hanushek, 2008), andragogy (Knowles,1984), transformative learning theory (Mezirow,1990), and institutional theory (Hanson, 2001) frameworks. For example, Hanson (2001) explains how organisations can learn and change their practices in order to become more intelligent. However, this theory has not, in general, been taken up; largely because institutions adapt to change in different ways to individuals (Burch, 2007). Knowles' (1984) principles of adult learning theory could also have formed a part of this study, but epistemologically and analytically they do not fit. They do not match well with the interpretivist and critical reflective principles underpinning this particular research. Instead, the constructivist and Mezirow's (1991) TLT were chosen because they fit more appropriately with the rationale for the purpose, problem statement, research purpose and research questions.

4.3.1 Transformative Learning Theory Framework

When considering the type of learning that the participants would be going through in this study, a theory was needed to inform the process of their reflection. Adult teachers are autonomous agents who would be critically reflecting in a collaborative context, as well as engaging with their environment (Mezirow,1997). The transformative learning theory is proposed as the main vehicle and appropriate theoretical framework for this study for two reasons. Firstly, being a well-established "theory of adult learning", with its underlying constructs of adult learners critically reflecting on their experiences, beliefs, and attitudes, in order to bring about transformation in their practices, it is appropriate as a guiding framework as to how adults learn (Mezirow, 1991:33). For example, Rogers (2001) reports that RP leads to transformative learning in teachers. Secondly, it allows the researcher to understand the classroom environmental structures and belief systems that trigger the transformative learning process, and thus influence the teachers' knowledge. Transformation learning can be understood as three notions or concepts, which are a process, an outcome, or a pedagogy (Fisher-Yoshida et al., 2009, cited in Nerstrom, 2014). TLT provided the lens for researching how RP impacts on the mathematical knowledge development of primary teachers in Seychelles. Some of the other adult learning theories which could also have been considered are andragogy, critical and postmodernism, and self-directed learning. The transformative learning theory as a model of reflection is a well-established theory and was first conceptualised by Mezirow and Marsick in the late 70s (Mezirow and Marsick, 1979). The root of TLT can be traced back to the seminal work of Paulo Freire's, Pedagogy of the Oppressed (Freire,1996) and rooted in the work of Habermas' (1971) theory of knowledge constitutive interests. Freire criticised the 'banking approach' or heavily teacher-centred approach to education in the 1960s. Mezirow (2003:58) defines transformative learning as learning:

> *...that transforms problematic frames of reference—sets of fixed assumptions and expectations (habits of mind, meaning perspectives, mindsets)—to make them more inclusive, discriminating, open, reflective, and emotionally able to change.*

Mezirow's seminal work is a well-established theory in adult education, about teachers constructing meaning knowledge through critical reflection. The theory is based on a study of adult women re-entering higher education in the 1970s. This current study recognises that such theory reflects a perspective of adult learning in the western world. Grounded in cognitive and developmental psychology, Mezirow's (1991) TLT is used to theorise the process of teachers' transformative self-reflection and self-examination of their worldview. This starts with learners encountering or experiencing a disorienting dilemma or compelling argument. They would then critically self-reflect on their beliefs, experiences, and current knowledge, thus leading to consequent transformation in their perspectives and actions. Sahin et al. (2016) explain that the term transformation emphasises radical change in the learner. TLT is also seen as a model which theorises the professional outcome of adult learning. On the other hand, Hoggan (2016:71) refers to transformative learning as "processes that result in significant and irreversible changes in the way a person experiences, conceptualises, and interacts with the world". The theory posits that learners view their world through a frame of reference consisting of points of view, assumptions, and habits of mind. The points of view which are presumed to have been absorbed from education, culture, the individual's upbringing, family, community, and life experience ultimately shape their beliefs, expectations and assumptions, leading to a compromised worldview. Mezirow (2000) explains that assumptions play a vital influential role on our actions by guiding choices and interpreting experience. Through self-critical reflection and self-examination, the learners' frame of reference (e.g. beliefs, assumptions and perspectives) is transformed, using rational discursive relationships as a validated reasoning approach, and leading to the making of a greater learner. Of particular interest to this research is the idea that the frames of reference are seen as descriptors which have been informed by culture. It is those descriptors that will be transformed through critical self-reflection. This is explained in Mezirow's own words:

> *Frames of reference often represent cultural paradigms (collectively held frames of reference) – learning that is unintentionally assimilated from the culture.*
>
> (ibid: 16)

As explained by Christie et al. (2015), the aim of TLT is to help the adult learner to change. This study sees TLT as a type of relationship-transformative-practice theory. When applied to this research, TLT posits that through reflection, active learning, and being placed in uncomfortable situations, teachers can potentially change their mindset, sets of assumptions, and expectations (e.g. views of themselves and the world, mathematical paradigms, stereotyped attitudes and practices, etc.) in order to transform their knowledge, guide future actions and promote higher concrete learning. Everyday classroom scenarios very often pull teachers out of their comfort zone and create uncomfortable situations, as described by Mezirow (1991). In such scenarios, teachers in the classroom would then need to consider their beliefs so that they could fit into any given scenario with their new experience and help to concretely understand their transformed problematic frames of reference and, thus, influence pupil learning (Christie et al., 2015). Mezirow (1991) also discusses the social aspects of TLT during the transformation process, where the adult would need to interact with other adult learners so that they can juxtapose their views with alternative perspectives (Mezirow et al., 1990).

4.3.2 Overview of the Transformative Learning Process

Self-critical reflection is seen as a crucial component in the constitution of TLT (Mezirow, 2006). It is only when teachers critically reflect on their mistaken beliefs in adulthood that there is a subsequent change in their actions, and they start thinking of alternative views, beliefs and possibilities. Especially, when teachers are not properly trained, a great majority of their beliefs, values and views can be unconsciously stereotypical, being influenced by the school culture, personal experience, and educational as well as sociocultural background. After the transformation of the teachers' problematic frames of reference, TLT assumes that adult learners see themselves as being in a better position than before, based on the fact that their problematic belief system has been challenged and modified to fit their current situation. Therefore, TLT is a self-examination development process which moves the personal, unchecked meaning and reality of adults to one that has been validated and established through rational discourse (Mezirow, 1991). Mezirow (2000) identifies ten phases of perspective transformation. Three critical descriptors in his theory are experience, critical reflection, and rational discourse. In order for the learners to develop their perspective and transform their frames of reference, they would need to go through ten ordered phases, as depicted above. However, Mezirow affirms not all ten steps must be in place for one to experience transformative learning. Once this phase is triggered, then the learners would start to critically reflect on their problematic frames of reference by examining their beliefs, values, assumptions, and habits of mind. This process involves a rational discourse which then leads the learner to a more inclusive worldview. In this process, Mezirow (2003) explains that the learner should be able to make use of two types of learning capabilities: which are, becoming critically self-reflective, and making reflective judgments. Reflective judgment is engaging in critical discussion in assessing one's assumptions, expectations, values, and feelings (ibid:60). Learners, in the final stage of reflective judgment, should be able to produce a viewpoint of their own perspective which is a vital condition of transformative learning. TLT, as a theory, is still being developed. New critical descriptors are still emerging from empirical studies, with critical reflection not being seen as the main influential descriptor (Taylor, 2009). However, in this study, critical reflection is taken as the dominant and influential construct in the perspective transformation equation.

A general application of TLT to education would see primary teachers entering the teaching profession with assumptions about the teaching and learning of their subject matter, their pupils, and themselves. In most cases, teachers are not aware that those assumptions have direct impact on their actions. Straight away, they are faced with the requirement to improve the learning outcomes of their pupils, which is a challenge for a teacher (Brock, 2010), and therefore, arguably, a disorienting event. They would then need to consider their frames of reference by critically reflecting on their teaching and learning assumptions and take action on reflected perspectives after they have been validated through a rational discourse. Duarte (2010:7) explains that transformative learning could be experienced through experiential learning; which is an appropriate pedagogical approach to foster reflection as it is a type of ethical minefield when the learners always ask themselves: "What is the right thing to do in this particular situation?" It is a learning process where teachers would make rational sense of their experiences. Research shows that activities such as roleplay, group discussion, and journal writing trigger and support transformative learning (e.g. Duffy, 2006; Brock, 2010). Literature reveals there are barriers to transformative learning. For example, Santalucia and Johnson (2010) write that not all adult learners are willing to transform their knowledge and are uncomfortable with the goal of transformative learning. This is because some adults are very comfortable with what they think they know and do not see the need to change their perspectives and would prefer to hold on to, what might be considered as, flawed belief systems. It is a common view that some teachers are not willing to critically reflect on their practices. A number of educational studies have applied Mezirow's theory to their work (e.g. Kumi-Yeboah and James, 2012; Christie et al., 2015; Feriver et al., 2016). For example, Feriver et al. (2016) applied Mezirow's theory in their study of early childhood teachers. Their study focused on the evaluation of an in-service teacher training programme about the perspective transformation in education for sustainability. The findings showed a range of transformations in the teachers' perspectives during and after the training workshop.

4.3.3 Critiques of Mezirow's Theory

While TLT is a widely-researched and well-established theory, it is not without its critiques, issues, and significant gaps (e.g. Hart,1990; Clark and Wilson, 1991;Tennant, 1993; Dirkx, 2012; Newman, 2012; Hoggan, 2016).The critiques exist even in the light of being seen as "a great asset to the scholarship of adult education; and has provided a solid theoretical base for understanding complex learning phenomena" (Hoggan et al., 2017:48). TLT has been tested, critiqued, revised and retested by various scholars, and some have even tried to reject it outright (e.g. Newman, 2012). However, it is worth noting that since the advent of the theory in the 1970s, Mezirow has refined and expanded on his seminal work taking into account theoretical critiques (e.g. Mezirow, 1990; 1991; 2000; 2009). TLT is being implemented in different areas in education. Various significant arguments and statements have been levelled either against TLT as a whole or against some of its descriptors (e.g. individual, critical reflection, experiences). In his criticism of TLT, Hoggan (2016) makes a common and valid point that the theory is loosely used to refer to almost any type of learning, and thus is being diverted from its original intention. However, Mezirow (1991) posits that even if learning involves a type of change in the learner; it is not considered to be transformative unless it has the element of self-critical reflection on the learners' worldview. Other critiques of TLT have focused on power, critical pedagogy, reflection, social action, context and rationality, and adult development (Taylor, 1997).

Despite the various interesting and valid criticisms, research in TLT continues to grow, and the researcher understands that Mezirow's theory has richly contributed towards the processes of perspective transformation. It is still a useful learning framework for educators, and a significant tool which helps to provide the understanding of the transformative learning process of adults. The mere fact that TLT focuses on the individual learner and their construction of meaning and knowledge makes it very relevant to this research as a theory. The researcher sees that TLT as a process has greatly informed and enhanced the understanding of this research on the transformative learning process of primary teachers.

4.3.4 Transformative Learning Theory in this Study

Even with much criticism and defence, the theory is being applied to several areas related to adult education (Uyanık, 2016). In this study, TLT is applied as a process referring to Mezirow's ten-phase process of transformative learning. The theory was applied when the participant teachers used Gibbs' (1988) reflective model to reflect on their practices. It was anticipated that as they reflected on their classroom events, 'disorienting dilemma', assumptions, expectations, and belief systems, in relation to their teaching of mathematics, they might find them to be flawed, too narrow, or mistaken, and therefore try to adjust them to fit their worldview, as well as their external behaviour and actions (Mezirow, 1991; Mezirow and Taylor, 2009). Sherin (2002) opines that some teachers enter the teaching profession with a fixed worldview and some firmly held beliefs about teaching. Consequently, the researcher speculated that the struggles of some teachers with their teaching may not be due to their limited natural intellect, but they could have issues with the transformation of their belief systems.

4.3.5 Social Constructivism and Mathematics Learning

This study is also partly grounded in the social constructivist paradigm because it is seen as an appropriate theory that supports knowledge construction, and the way participants in this study would "interpret and reinterpret their sense of experience" (Mezirow, 1991). To understand the process of teacher learning and knowledge development, it is important to differentiate between mathematics learning theories and mathematics instruction perspectives. The theory of mathematics learning could be divided into four main schools of thought which are behaviourism (e.g. 'skill and drill' teaching of mathematics), cognitivism (e.g. mathematical knowledge as internal mental constructs), constructivism (e.g. mathematical knowledge as a construct of the learners' mind), and social constructivism (e.g. mathematics learning as grounded in social context). For this study, the social constructivist theory which is the current dominant pedagogy is chosen out of the four main theories of mathematics. Social constructivism, as a derivative of the constructivist theory is derived from the seminal work of Vygotsky (1978). Vygotsky's (ibid) theory which can be referred to as the sociocultural view of cognitive development, is more concerned with the social aspect of a learner's performance (Smith et al., 2009; Albert, 2012; Bartlett and Burton, 2016). Its primary concern is understanding the construction of the teachers' mathematical knowledge and pupils' learning. This thesis uses the social constructivist principles to explain and ground the study in the theoretical perspectives that the transformation of the teachers' frames of reference and construction of knowledge is grown out of a “collective human action” (Collin, 2013). Cobb et al. (1992) argue that the learning of mathematics should be seen as being both cognitive and social; involving construction, interaction and problem solving. The fact that learning involves the construction of knowledge, while reflecting on their practices (e.g. reflection on action), the teachers could construct and develop new MKT (Ottmar et al., 2015). Vygotsky’s socio-cultural theory has been criticised for not considering the mind of the learner separate from the group (Lui and Matthews, 2005). The socio-constructivist paradigm is relevant to the study as it is still a dominant learning theory in mathematics education and provides a profound understanding of the sociocultural factors involved in the construction of teachers’ knowledge. The choice and significance of Vygotsky’s constructivist theory to this research is that it helps to understand how the teachers connect new experiences to prior knowledge, and that the construction of knowledge is affected by sociocultural factors. Vygotsky’s theory stresses the importance of social interaction and scaffolded support in the learning process (Bartlett and Burton, 2016).

4.3.6 Social Constructivism and TLT

The constructivist nature of the transformational learning theory (TLT) is derived from the fact that adult learners have prior knowledge and experience which they use as baselines and frames of reference as they start engaging in the transformation process. Literature explains that constructivism is the foundation of (TLT). Cranton (2006) opines TLT is underpinned by the constructivist paradigm which asserts that meaning is personal not external to the learner, but rather exists and is derived from within. Constructivism posits that learning is contextual and personal meaning would need to be validated by others (ibid). TLT is based on the social constructivist paradigm because it supports the common view that personal meaning is constructed and validated through a social discursive relationship. As explained by Mezirow (2000), learning happens by the learner critically reflecting on their own assumptions. Despite the richness and value of Mezirow’s theory, it does not explain in depth the knowledge construction of the teachers beyond critical reflection and rational discourse. Therefore, the constructivist paradigm complements Mezirow’s theory by providing a deeper perspective of how knowledge construction takes place in the learner. Moscardini (2014) explains that when teachers learn about themselves by reflecting on their existing beliefs and practices, a constructivist perspective is relevant to frame their actions, which would indicate how the teachers and pupils learn. This is also proposed by Gresham (2007) who suggests that constructivism principles are used to support adult learners overcome mathematics anxiety which can have a negative effect on their learning. The basis of the theoretical frameworks in this study is the understanding that when reflecting on their practices, teachers are acting like self-directed adult learners, building on their prior knowledge to construct new knowledge, and seeking ways to improve their teaching by recording their experiences for future action (Merriam et al., 2007; Sagor, 2011). This claim is bolstered by York-Barr et al. (2006:33) who observed that “when adults enter any learning situation, they immediately begin to filter information based on the depth of their knowledge about such situations, as well as on their relevant repertoire of life experiences”. This reflects, encompasses, and is consistent with the constructivist learning theory. The aforementioned literature makes the association between RP and the constructivist paradigm through the insinuation that both principles allow learners to build on their prior knowledge; thus, implying that reflecting to construct new meaning is inter-woven within the social and constructivist paradigms. Also, Osterman and Kottkamp (1993) perceive RP as experiential learning, with roots in the constructivist paradigm. Osterman and Kottkamp’s view is supported by that of Turner (2012) who explains that the development of teachers’ knowledge is underpinned by a constructivist perspective. Therefore, the research makes the assumptions that reflection is an integral part of constructivism and is one of the components of the social constructivist theory that drives forward the creation of new knowledge.

4.4 Chapter Summary

This chapter has explained and justified the choices which comprise the conceptual and theoretical frames for the study. Firstly, Desimone’s (2009) conceptual framework was presented, and discussed in terms of how it may be used to contribute to an understanding of the professional development of teachers. The adapted conceptual framework of Desimone is a type of nested model comprising five features of an effective professional-development programme within a parent link-chain model of professional development. Desimone’s model is based on research-proven, interlinked elements and concepts which have the potential to enhance learning. The framework summarises the current literature status on effective PD by depicting change in learning outcomes of the pupils depending on how much the PD has affected the various components of the teachers’ domain. The adapted framework was applied by the researcher to implement the professional development of the teachers (see Section 5.10.3). The framework sees effective PD programmes as the initial triggering machinery of change. The themes featuring in the different components of the conceptual framework influenced the design of this study and its data analysis. The chapter also provided an overview of TLT and constructivist principles as the theoretical frameworks which underpin this study, in order to analyse the case studies and RP of the participants. The use of the seminal work of Mezirow has enlightened this study on how to view and understand adult learning, as well as adult pedagogy. TLT is critical to this research because it helps to understand how teachers make their own interpretations of events or dilemmas in their classrooms in order to transform their ‘habit on mind’ and ‘point of view’ through critical thinking. It also provides a framework to understand how the participants critically reflect on their assumptions through rational discourse to transform their worldviews. The theory also represents a reflective model where adults reflect on their reasoning to transform perspectives. In this study, the TLT descriptors are used as an analytical framework to explain how teachers transform their mathematical knowledge through RP using Gibbs' (1988) reflective model. Similarly, the constructivist and sociocultural-based principles underpin the process of teachers actively interacting with their teaching environment to construct their knowledge. The next chapter presents the methodology of the study.

Chapter 5: Methodology

5.1 Introduction

In the previous chapter, the conceptual and theoretical frameworks were examined. This chapter presents the methodology of the study. After the presentation of the researcher's voice in Sections 5.2, Sections 5.3, 5.4, 5.5, 5.6 and 5.7 respectively justify the ontological and epistemological perspectives, research design, and methodological approaches used to answer the research questions. Sections 5.8 and 5.9 discuss the pilot study and steps taken to ensure the validity and reliability of the study. Sections 5.10, 5.11 and 5.12 explain the data collection procedures and the analysis. The penultimate section discusses the ethical considerations, and Section 5.14 summarises the chapter.

5.2 The Researcher's Voice

From the outset of the study, it is important for the researcher to be explicit about determining factors which have influenced the methodological approach of the study. I avoided following the research tradition by taking a pure positivist or interpretive stance towards the study. On the contrary, it was important to be objective and allowed the research problem to dictate the best approach. The general idea and purpose behind this educational research were to investigate the phenomenon at hand, and then adopt procedures to change or "improve existing knowledge, policy and practice" (Basit, 2010:1) which, in most cases, improves pupils' learning. The research is based on an education phenomenon which is under-researched. One point of interest was to explore the participants' personal experiences and the effect of the intervention, so that a school-based professional development approach could be identified for their future improvement. This qualified the research to be explored within a pragmatic paradigm (Johnson and Onwuegbuzie, 2004; Yin, 2018), and a harmonious blend of subjective and objective voices (Johnson and Onwuegbuzie, 2004; Zhou and Hall, 2018).

5.3 Philosophical Perspectives and Assumptions of the Research

Before the methodological footprint of the study is laid out, the guiding philosophical perspectives need to be known and rationalised, as they dictate the methodologies appropriate for the study. Crotty (1988) proposes that researchers should consider four questions when designing a research study. The questions are: What epistemology informs the theoretical framework? What methodology governs our choice and use of methods? What theoretical perspective lies behind the methodology in question? What methods do we propose to use? All these questions are considered in this study. There are different approaches to research and all research is underpinned by ontological and epistemological assumptions.

5.3.1 Ontology

Whilst Denzin and Lincoln (2018:19) define ontology as “what is the nature or reality?”, Braun and Clarke (2013:27) define it as “whether or not we think reality exists entirely separate from human practices and understanding”. Thus, ontology concerns the beliefs about reality or the theory of reality. The quantitative and experimental aspects of social science are also underpinned with the ontological realist belief of a real world waiting to be discovered (King, Horrocks and Brooks, 2019). On the other hand, there is the relativist ontological belief that rejects the view of a real world and embraces the view that the world is formless and diverse, and our understanding and experiences of the world are specific to our social world and frames of reference. That is, there is no real world out there, and knowledge is constructed. Bryman (2016) explains that there are two different positions taken in ontology and they are: objectivism and constructionism. Objectivism is “an ontological position that implies that social phenomena confront us as external facts that are beyond our reach or influence” (ibid:29). Similarly, constructivism is “an ontological position that asserts that social phenomena and their meanings are continually being accomplished by social factors” (p.29). The quantitative component of this research is influenced by the realist ontology and similarly the qualitative component of the research subscribes to a relativist approach. This study is driven by a relativist ontology of multiple realities from the view of the teachers when reflecting on their practices when investigating and understanding the experiences of ongoing professional development. However, it also aligns itself with the realist ontology to obtain a more comprehensive finding of the phenomenon being studied.

5.3.2 Epistemology

Epistemology is the philosophical theory of getting the knowledge or reality. Cohen, Manion and Morrison (2018:5) define epistemology as “nature and forms of knowledge, how it can be acquired and how it can be communicated to other human beings”. It is about how we arrive at knowledge. Denzin and Lincoln (2018) define it as the relationship between the learner and the known. The epistemological position also takes three distinct stances which are: objectivism, constructionism and subjectivism. Objectivism stipulates that it is possible to access existing knowledge in the real world objectively (e.g. experiments). Constructionism declares that knowledge is not objectively accessed, but rather constructed by people. Subjectivism promotes the idea that individuals can impose their truths on the world based on their self-awareness and preconceived views. The epistemology of this research is that the knowledge with regard to RP of the teachers is subjective. The ontological questions of what sort of reality exists out there in the world, or whether there are single or multiple realities, and similarly the epistemological questions of how to access the knowledge or reality, have been issues of philosophical debate over the years (Bryman, 2016; Cohen et al., 2018). The debate has led to two distinct positions in research traditions. They are the positivist and interpretive paradigms. These two paradigms are now discussed below.

5.3.3 The Positivist Paradigm

The positivist stance is that there is an objective reality out there in the world, and it exists independently of the individuals within it, and “is something that has to be discovered” (Savin-Baden and Major, 2013)**.** Taking such a stance for this study would mean that knowledge is external to the researcher. Therefore, one of the epistemological positions of the positivists is that reality can be studied independently of the researcher. Similarly, one of their ontological positions is that social reality is independent of consciousness. Such a view is different from the interpretivist view where knowledge is derived from interaction with the social world. Adopting the purely post-positivist paradigm in this research would have made the researcher take on the foundation of ontology, where knowledge construction of the teachers cannot be observed and co-constructed. In such a case, knowledge has to be tested purely through hypothesis, experiment, and use of statistical analysis and quantitative methods of data collection, such as a survey (Cohen et al., 2018). It would then mean that social reality could be studied independently of the researcher. If this was the only adopted paradigm, then this study would have missed the essence and human subjectivity of teachers reflecting on their practices.

5.3.4 The Interpretive Paradigm

Interpretivists see reality from a different perspective compared to the positivists. They believe that there is no single reality; instead, there are multiple realities, and all observations are both theory- and value-laden (Leitch et al., 2010). The interpretivist seeks to understand the world from a subjective viewpoint. Cohen et al. (2018:19) emphasise that the interpretive paradigm “is characterised by a concern for the individual”. Interpretivist researchers very often adopt a constructivist approach to reality in which reality is subjective and constructed in a social environment (Braun and Clarke, 2013). Therefore, one of the ontological assumptions that the interpretivists use for their research is that the nature of reality is subjective and socially constructed. On the other hand, one of their epistemological assumptions would be that theories inductively emerge from the data as the study progresses, which later could be tested with deductive research. Such an empathetic stance typically leads to qualitative research. Adopting the interpretive paradigm for this research made the researcher use an inductive research approach when searching for meaning in the data. It also means the methodological approach used should allow the researcher to understand how the teachers make sense of their subjective reality.

5.3.5 The Ontological and Epistemological Assumptions Underlying this Study

Researchers in the field of education tend to adopt a research position based on their philosophical preferences. The researchers then approach research using the positivist or post-positivist paradigm and end up with pure quantitative studies, while some would take an interpretive stance involving qualitative research. Irrespective of philosophical perspectives, I take a pragmatic lens and argue that researchers should focus on the nature of inquiry and context, rather than on personal research positions as agents of influence (Savin-Baden and Major, 2013; Cohen et al., 2018). I also believe that beginning researchers should be engaging with both philosophical positions in order to obtain research experience. Savin-Baden and Major (2013:70) argue that “personal stance can affect researchers’ views about research context and participants, a process that is connected inherently to the notion of bias”. Competent researchers should be able to pick up and use any research paradigm and methodology to solve a particular research problem. On the other hand, there seems to be no clear demarcation in terms of application between the positivist and the interpretive stance on research. For example, qualitative research design can still be used outside a qualitative paradigm. There, the qualitative data can be converted to numerical values and then statistically analysed, making it a qualitative research with a positivist ontology. This means the choice of methods chosen by the researcher is not dictated by a particular ontological stance. Proponents of mixed-methods research, such as Johnson and Onwuegbuzie (2004), Teddlie, and Tashakkori (2009), and Biesta (2017), argue that decisions concerning research design and methods should be driven by the aims, objectives, and research questions, rather than a particular research paradigm. Therefore, in the study the researcher conceptualised the design of the study by focusing on the research problem rather than on personal research positions. Irrespective of the two traditional research designs, the nature of educational research is to explore complex phenomena in order to bring change, and therefore a mixed methodology was useful (Basit, 2010). In this study the researcher integrated a quasi-experiment within an inductive design to answer the research questions. The research case involves investigating the experiences, knowledge and practices of teachers in order to obtain a deep understanding. Therefore, the research should use an interpretive paradigm (Bassey, 1999). This means using a subjective research epistemology in conjunction with an ontological belief that reality to the teachers would be socially constructed. Such adopted epistemology will later determine and guide the data analysis in this study. The interpretive paradigm allows the meaning and perspectives of the teachers to be interpreted.

5.4 Quantitative and Qualitative Methodologies

Methodology is about “what procedure or logic” the researcher should follow in order to answer the research questions” (Waring, 2017:16). When referring to the nature of the research questions, it would not have been possible to answer them using a single methodological approach. Therefore, this study combined two different methodological approaches in order to collect the appropriate data.

5.4.1 Quantitative Methodology

Quantitative methodology aligns itself with the positivist paradigm. Quantitative studies carry with them the ontological assumptions that there is a single reality, which should be tested objectively through hypotheses (Basit, 2010). The quantitative methodology was chosen to measure educational phenomenon with precision (Ponce and Pagán-Maldonado, 2015). This study has been partly conducted using the quantitative methodology. This is because it required that any existing relationships and significant differences among RP, MKT, and self-efficacy were analysed. Despite some claims in literature that RP improves teachers’ knowledge (e.g. Alsina and Mulà, 2019), this has never been tested and validated in the case of a developing country like Seychelles. Therefore, including a quantitative approach in the study allows data to be compared in a systematic way. Moreover, the fact that the evaluation of reflection is often recognised as being too subjective, a quantitative methodology should help to bring a balance in the analysis.

5.4.2 Qualitative Methodology

Qualitative methodology aligns itself with the interpretivist paradigm. Savin-Baden and Major (2013:11) define qualitative research as an investigation “of the way in which people make sense of their ideas and experiences”. The researcher framed the study in such a way that the phenomenon could be observed and questioned. The use of the qualitative interpretive approach is “to grasp the subjective meaning of the social action” in context as perceived by participants (Bryman, 2016:30). One of the significant advantages of such an approach is that it can illuminate the participants’ experiences in detail and with great depth of understanding. Qualitative design uses small, purposeful samples as opposed to probability sampling. The chosen approach for this research is partly qualitative, because such an approach allows the attitudes and feelings of the participants to be obtained. Nevertheless, qualitative research is often criticised for being short of scientific rigour, limited in justification of methods adopted, inadequate in analytical procedure, and for lack of subjectivity by the researcher (Rolfe, 2004). Qualitative data in this study took the form of semi-structured interviews with the participant teachers, reflective journals of participants, and the researcher’s field notes. Leech and Onwuegbuzie (2007) posit that qualitative data can be used in experimental studies (e.g. quasi-experiments) to support and strengthen the quantitative research design. However, in this study the quantitative data analysis was used to strengthen the qualitative research design.

5.5 Research Design

The framework of this study is a mixed-methods research design. This methodological approach in particular merges qualitative and quantitative methodologies within an experimental case-study design in order to provide a more comprehensive picture of the phenomena (Creswell et al., 2018; Cohen et al., 2018), as opposed to using a single method. Also, Johnson and Onwuegbuzie (2004:14-15) point out the "goal of such design is to draw from the strengths and minimise the weaknesses of both in single research studies and across studies". To minimise their limitations, in this study these two designs are combined in order to maximise their strength.

5.5.1 Method of Investigation

This study adopted a multiple case-study approach to investigate the RP of the teachers. The following five research questions below were established to investigate this multiple case study:

1. To what extent do the MKT sub-domains and MKT self-efficacy beliefs of primary teachers develop after engaging in RP?
2. Is there a statistically significant difference between the MKT sub-domain scores of the intervention and control groups after engaging in RP?
3. To what extent does the MTSE level of primary teachers change after engaging in RP?
4. Is there a statistically significant difference between the MKT self-efficacy beliefs of the intervention group and control group after engaging in RP?
5. Is there a statistically significant difference between the MTSE level of the intervention and control groups after engaging in RP?

Justifying the purpose of using a case-study framework for the research is important (Hammersley, 2010). The justification is fourfold. First, 'what' questions are being asked about a phenomenon about which the researcher has no previous knowledge (Cohen et al., 2018; Yin, 2018). Second, the study requires detailed intensive knowledge of how being involved in reflection-based mathematics teaching affects the MKT development and self-efficacy of teachers. Third, the problem being investigated is justified by the literature review as being different from other cases, and thus requires a detailed investigation. Fourth, the phenomenon of teachers' RP and its impact on their MKT and self-efficacy is an un-researched subject in the case of Seychelles, and the researcher felt that the exploration could not be done otherwise (Stake, 1995; Ashley, 2017; Yin, 2018). Additionally, the case study allowed the naturalistic exploration of the primary teachers' MKT and self-efficacy change to be conducted in sufficient depth and detail. However, the case-study approach should not be used naively. The case-study approach to research is constantly being criticised on the grounds of lack of generalisability. Lichtman (2011) and Thomas (2017) argue that it is not the intention of the case study to generalise over populations; whilst Punch and Oancea (2014) also explain that generalisation should not be the objective of all research. However, Stake (1995:8) explains that “valid modification of generalisation can occur in case study”. Similarly, the aim of this multiple case-study design was not to generalise the cases, but to understand the complexity of the phenomenon through within-case and cross-case analysis. In this study, the researcher believes that a properly conducted case study could make an invaluable contribution to education; to a phenomenon that is not properly understood.

5.5.2 Mixed-methods Approach

Mixed-methods research is an emerging research approach in social enquiry, which combines two dominant research designs: the participants’ voice, as well obtaining a comprehensive picture of the phenomena being studied. Johnson and Onwuegbuzie (2004) argue that the use of mixed methods renders superior research results compared to single research methods. They defined mixed methods as a study “where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study” (p.17). Additionally, it is recognised that educational research can be a highly complex phenomenon and would therefore require the joint application of quantitative and qualitative methodologies (Ponce and Pagán-Maldonado, 2015). Furthermore, the fact this study has a case-study design, the mixed-methods approach enables a more comprehensive understanding of the building of the case. The researcher also wants to ratify the qualitative data with quantitative data. In this research, it involves putting together the qualitative stories told by the teachers regarding their practices, and the statistics or numbers which would quantify what occurred. Such combination would provide a more candid picture and understanding of the phenomenon than either qualitative or quantitative data alone (Cohen et al., 2018). The approach chosen for this research is a convergent parallel mixed-methods study design, to collect, analyse, and interpret quantitative and qualitative data (Creswell et al., 2018). The researcher wanted to better understand the effects of RP on the MKT and self-efficacy for teaching arithmetic word problems by merging qualitative data from reflective journals, interviews, and open-ended survey questions with that of quantitative data from the survey and tests.

5.5.3 Case-study Methodology and its Critiques

The research is based on the specific real-life context of several primary teachers teaching mathematics, and therefore adopts a qualitative multiple case-study framework (Merriam, 1998; Bryman, 2016). Case studies continue to play an important role in educational research (Hamilton and Corbett-Whittier (2013). Tight (2010) informs us that the case study includes a detailed investigation of a sample of interest from a particular perspective. In this present case study, the case is seen as the subject being studied (e.g. teachers); and the purpose or object of the study is to obtain a detailed and in-depth understanding of their RP experience. Whilst Yin (2018:15) defines case study as "an empirical method that investigates a temporary phenomenon in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident", other scholars (e.g. Bassey, 1999; Basit, 2010; Savin-Baden and Major, 2013; Creswell et al., 2018; Bryman, 2016), also point out that the case study is a way of framing a rich and in-depth examination of a subject or case. The research did just that by taking an interpretive multiple case-study design and explored an educational phenomenon in depth using multiple sources of evidence. The cases in consideration in this study are detailed accounts and analysis of primary teachers reflecting on their practices to enhance their MKT and mathematical self-efficacy. The defining characteristic of this case study is the intensive examination of the effect of RP on the MKT and self-efficacy of teachers (Lichtman, 2011). This research uses a cross sectional, multiple case-study design, where the study of the different cases is bounded by time, activity, and place (Lichtman, 2011; Creswell and Creswell, 2018). Despite the advantages of case studies, the literature reveals some disadvantages, which are, in most cases, due to common misunderstandings. Some of those misunderstandings have been addressed by scholars (e.g. Flyvbjerg, 2006; Yin, 2018). For example, Yin (2018) writes that "too many times, a case-study investigator has been sloppy, has not followed systematic procedures, or has allowed equivocal evidence to influence the direction of the findings and conclusions" (ibid:18). Here, Yin (2018) encourages researchers to avoid such practices. However, the use of the case study is widely reported in educational research. For example, in a recent study Geiger et al. (2017) applied a case-study design to investigate effective practice in mathematics teaching and learning in one Australian state. The study was found to be necessary after the country's sharp decline in the TIMSS and PISA. The purpose of the study was to examine the case of one successful school, to build evidence of best mathematics practice nationally.

5.5.4 Survey

Fink (2013:1) describes the survey as a type of research approach "used to collect data about people in order to describe, compare or explain their knowledge, feelings values and behaviours". Educational surveys typically use self-administered questionnaires and structured interviews which are usually administered through the conventional mail, telephone or online. One of the marked advantages of a survey is that it allows the researcher to collect direct data from the participants. In this study, a self-administered survey questionnaire was designed and completed by the participants.

5.5.5 Integrating Quasi-experimental and Inductive Designs

Street (1995) and Tymms (2017) explain interventions in educational research as assigning pupils to different treatments in order to test the effect of classroom instruction in terms of hypotheses (see Section 6.1.2). Intervention studies are conducted by demonstrating that the manipulations of the intervention variable produce different effects on another variable or so-called dependent variable. Apart from making sure like is being compared with like, so that there would not be any threat to the validity of interpretations (Tymms, 2017), researchers must also exercise control over extraneous variables that could threaten the internal validity of the study. That is, whether one can claim causal inference in the sense that the intervention has had an effect on the teachers' practices. A quasi-experimental, pre-post design with non-equivalent control groups was applied to the study (Christensen, 2004; Ross and Matthews, 2010; Moyer-Packenham and Westenskow, 2012; Cohen et al., 2018; Creswell et al., 2018). This study consists of a two-group, quasi experimental design, with intervention and control groups. A quasi-experimental design was found to be appropriate for the research to test the research questions and to complement the case study approach. The quasi-experimental approach sought to establish if there were changes over time in the teachers' MKT and self-efficacy, and how large were those changes (Creswell et al., 2018). Therefore, from this positivist stance, the researcher wanted this part of the research to remain objective. Moyer-Packenham and Westenskow (2012) explain that pre-post-testing of teachers is the most common approach for measuring teacher MKT growth. However, in this study the experimental data were used to provide empirical evidence of change in the practices of the teacher rather than to make generalisations.

This study integrated a quasi-experimental methodology within an inductive qualitative design. Quite recently Green et al. (2015) used methodological triangulation and integrated a quasi-experimental and inductive design in a case study to investigate the impact of free bus travel on public health in London (UK). Biesta (2017:160-161) explains that it is "relatively uncontroversial to combine different data, different data collection methods, and different data analysis strategies within the same study"; as well as "combining different designs within the same study". This study shows how integrated research design contributes in important ways towards how the professional knowledge of teachers could be enhanced.

5.6 Research Methods and Case-study Instruments Development

Method is interpreted as the “techniques or procedures” used to collect both qualitative and quantitative data (Waring, 2017:16). The methods for this study consist of survey, tests, semi-structured interviews, reflective journal, and field notes. Each method contributed differently to each research question. Table 5.1 (see Appendix 1) outlines the data sources, methods and analysis, as linked to the research questions.

5.6.1 Interviews

Savin-Baden and Major (2013) and Bryman (2016) consider the interview as a common method of data collection for qualitative research, and which allows complex and personal information to be collected from the participants. Two marked advantages of using interviews in research are that they allow for the gathering of the participants’ experiences, beliefs, and feelings, and produce a high response rate (Denscombe, 2010). In-depth, semi-structured interviews were used to capture rich, descriptive data from the teachers’ subjective perspectives on their reflective lessons, and their perceptions of MKT. The interviews were face-to-face, conducted in each teacher’s school. The interviews were audio-recorded and transcribed as soon as possible after a school visit. The audio recordings of interviews helped the researcher to cross-validate the qualitative results. The researcher developed an interview protocol (see Appendix 2) which consisted of open-ended questions which allowed the researcher to catch “honesty, depth of response, richness of response” (Cohen et al., 2018). The interview protocol was informed by key theories of MKT (e.g. Ball et al., 2008). The interview protocol elicited information around the teachers’ perceptions, experiences, knowledge, and practices. The researcher transcribed the interviews for data analysis.

5.6.2 Reflective Journaling

The reflective journal is one amongst many methods, such as reflective interviews, group seminars, and electronic portfolios, which can be used to encourage teachers to reflect (e.g. Ahmed, 2020). Boud (2001:18) defines reflective journal writing as “a multifaceted activity that can take many forms for many purposes”, of which one of them is the promotion of reflection. The reflective journal prompt in this study was developed by the researcher and guided by the six dimensions of Gibbs’ (1988) reflective cycle (see Appendix 3). It was used to provide a structure for the participants’ reflective writing (Williams, 2017). This allowed the identification of significant statements that revealed the type of MKT and self-efficacy development with time. The participants were asked to complete reflective journals which were submitted on a weekly basis throughout the ten weeks of intervention.

5.6.3 Questionnaire Survey

The questionnaire survey is a well-established data collection method and is used widely in educational research to collect large amounts of quantitative, valid, and unbiased primary data from participants (Cohen et al., 2018). A self-administered questionnaire was considered the most viable way to collect quantitative data from the participants. However, the information generated can be subject to errors, since it is based on the underlying assumption that the participants would be willing and able to give honest answers (Burns, 2000). In this study, the researcher used self-administered questionnaires. The objectives of using the self-administered questionnaire were to identify the self-perceived expertise of primary teachers in their MKT and self-efficacy. To measure the self-efficacy of the teachers a fifteen-item, Likert-scale instrument of self-efficacy was developed to assess the teachers' efficacy beliefs in using specific MKT sub-domains in relation to arithmetic word problem solving. The teachers were asked to rate themselves on how they would address specific teaching and learning issues. The internal reliability of the instrument was calculated resulting in an acceptable Cronbach's alpha coefficient of 0.830. Even if it varies in the literature, Cronbach's alpha is mostly accepted in the range 0.70 and 0.95 (Tavakol and Dennick, 2011). The self-efficacy questions were included in the pre- and post-questionnaires. Two almost identical teacher questionnaires were designed, and the researcher made sure that they were not too lengthy (Tymms, 2017). One was used as a pre-intervention questionnaire and the other one was used as a post-intervention questionnaire. The significant difference between these two questionnaires is that the post-intervention questionnaire consisted of some open-ended questions at the end which were used to obtain information on their RP experiences. The pre- and post-intervention questionnaires were designed to examine the teachers' MKT and mathematics teaching self-efficacies before and after the intervention respectively (see Appendices 11 and 12). One of the reasons for including the open-ended questions was to capture a range of possible responses by giving the respondents the opportunity to express what was on their mind. All the questions in the questionnaire were derived from the literature on MKT (e.g. Ball et al., 2008), RP, and mathematical problem solving. The pre-intervention, self-administered questionnaire was split into five main sections consisting of forty-items, with thirty-seven Likert-scale items. The post-intervention, self-administered questionnaire consisted of fifty-one items, with thirty-seven Likert-scale items. Like the pre-intervention questionnaire, the post-intervention questionnaire consisted of five different Likert-scale measurements and sets of closed and open questions.

5.6.4 MKT Tests

An MKT, pencil-and-paper, non-standardised instrument was developed by the researcher to measure teachers' MKT (see Appendices 17 and 18). The content of the items was based on the type of knowledge primary teachers would need to have in order to effectively teach primary mathematics. The MKT items development was guided by the national mathematics curriculum, examination reports, teacher training syllabi, and feedback from the teachers. The content of the test items was based on MKT primary mathematics and covered curriculum content in the areas of number concepts, operations, and problem solving. These aforementioned sources were used to ensure the content validity of the test instruments. The test was administered to all the participants as both pre-test and post-test. The validity of the test instrument was established by the researcher who asked experienced mathematics teacher trainers working at SITE, and three mathematics coordinators working in the three pilot primary schools, to validate the test items. Their comments were used to finalise the instrument. The researcher sought opinions about what the items were thought to be measuring. Based on the feedback, the items were then revised. The teachers' tests consisted of multiple-choice items and open-ended questions related to Ball et al.'s (2008) MKT framework which assessed teachers' knowledge for teaching primary mathematics. There was only one possible correct response to the multiple-choice questions. The test was constructed to capture five of the six MKT sub-domains: CCK, SCK, KCS, KCT and KC. Horizontal content Knowledge (HCK) was ruled out because it was not easily measured, and moreover the researcher wanted to focus on the knowledge type that can be measured through teaching at primary level. As pre-test survey data, the teachers' (intervention and control groups) performance on the five MKT sub-domains was measured using an instrument comprising of multiple-choice test items. The MKT test items for the instrument were based on existing theories about teacher knowledge (e.g. Ball et al., 2008; Hill, Schilling, and Ball, 2004). Both pre- and post-tests and their rubrics were developed by the researcher.

5.7 Mnemonic Strategy (PIES)

One of the strategies used in this study for teachers to develop their MKT was to focus on specific mathematical content, and the way pupils learn it (Desimone, 2011; see Section 4.2.1 on Content Focus). The chosen mathematical content was solving word problems. Mnemonic strategies (e.g. CUBE, PIES, STAR, RUCSAC, BUCKS, FISH, RIDE) have been found to be very useful in helping pupils solve arithmetic word problems (Scruggs et al., 2010). The PIES mnemonic strategy was used by the teachers in this study to help their pupils solve arithmetic word problems. PIES is one of the strategies used to implement George Polya's (1973) now classic four-stage model of problem solving: *understand the problem, devise a plan for solving it, carry out your plan, look back to examine your solution (*Smith et al., 2009). PIES mnemonic strategy has been chosen for this study because it overcomes some of the drawbacks of the other strategies by allowing pupils to make a visual representation of the problem through the use of drawing.

A lot of otherwise able pupils have reading difficulties; and word problems become a real challenge for them. Even if they still need to read the given problem, the pictorial aspect of PIES could help them to overcome their language issues when interpreting the problem. It is also less procedural when compared to the other strategies, and more appropriate for lower primary pupils. It also involves the learners in a bit of reflection. The acronym PIES has the following meaning:

P	Draw a **P**icture (make a pictorial representation of the problem)
I	**I**nformation (pull out the necessary information to solve the problem)
E	**E**quation (write down the operations to solve the problem)
S	**S**olution (write the solution to the problem)

A PIES card was developed by the researcher and given to the pupils to help them implement the PIES mnemonic strategy (see Appendix 4).

5.8 The Pilot Study

Prior to the main study, pilot trials were conducted in order to ensure greater reliability, validity and clarity of the research instruments (Straub, 1989; Creswell et al., 2018; Cohen et al., 2018), and to gain experience in the research process in order to answer the research questions. Three pilot schools were chosen to refine the data-gathering instruments. The methodology for the pilot study was structured in the same way as the main study. The data collection instruments were the questionnaires, tests, interviews, and journals. The final versions of the instruments are found in the appendices of the thesis. The pilot study provided insights into how to improve the design of the main study, and supported the use of questionnaires, interviews, tests, and journals to conduct the main study. Overall, the pilot study justified the research methods used for the main study.

5.8.1 Piloting the Questionnaires

Lowe (2007:57) explains that a pilot questionnaire enables the researcher to “check if the questions are worded clearly, and to identify misunderstandings in the questions’ instruction”. Cohen et al. (2018:496) agree that a pilot has the function of “increasing the reliability, validity and practicality of the questionnaire”. The researcher tested the questionnaires with fifteen primary school teachers in two pilot schools and with two mathematics education teachers at the school of education. The questionnaires were piloted during the month of October 2018. The self-administrating pre- and post-questionnaires were piloted with a sample size (n=20) of purposefully selected respondents in order to get maximum feedback from their various levels of teaching. Three different primary schools on the main Island of Mahé were chosen as pilot schools. The primary purpose was to detect and correct weaknesses in the instrument (Straub, 1989). However, it was not possible to get direct access to the teachers because they were in teaching sessions. Therefore, the questionnaires were given to the mathematics coordinators to distribute to the teachers. Participants' responses to the questionnaires suggested that they understood most of the questions and terminology used. However, it was revealed that it was necessary to improve on the clarity of questionnaire by re-phrasing three questions because they were interpreted differently by different respondents. There were no issues with the design of the questionnaires.

5.8.2 Piloting the Interview Protocol

In-depth interviews can be a daunting task for inexperienced researchers. The piloting of the qualitative interview guide was found to be necessary and an integral part of qualitative research (Cohen et al., 2018). It was necessary to identify possible flaws, unclear or ambiguous items in the questions (Wiersma and Jurs, 2005; Lowe, 2007) in order to increase the validity of the instrument by improving the interview protocol. For this study, the interview schedule was subjected to pilot testing during the month of January 2019 with six participants in two pilot schools. Like the questionnaires, sampling for the piloting was not a random event, but carefully orchestrated to reflect the features of the main study sample (Hennink, Hutter and Bailey, 2011; Maxwell, 2013; Cohen et al., 2018). The pilot interview offered insights into the teaching practices of the teachers and helped to improve the interview protocol. Firstly, based on the interview responses, the researcher changed the problem-solving mnemonic strategy from FISH to PIES which is a more appropriate one for primary school pupils. Secondly, two of the interview questions were rephrased to allow deeper responses, to avoid repetition, and to allow the participants to make their experiences more explicit.

5.8.3 Piloting the Quasi-experiment Test

The quantitative element of this research involved a quasi-experiment using a mathematics pre-test and post-test. The test was designed to test the MKT of the teachers before and after the intervention. The pre-test and post-test tests were exact replicas of each other apart from their titles. To determine the validity of the content of the test, the researcher sought expert validation of mathematics education teachers at SITE. The tests were administered to fifteen purposefully selected participants from the three case schools. The test was piloted and administered to teachers teaching in Primary 1 to Primary 6. The purpose of the piloting was to check the validity of the test and for ambiguous use of language. Using feedback from the teachers some of the questions were revised to present more clarity in the wording.

5.9 Validation and Trustworthiness

When conducting research, most researchers aim to produce high-quality research. When such an objective seems to have been attained, they may claim that there is validity while others may claim that their research is trustworthy. Bailey (2018) clarifies that for a piece of research to have validity, it must have internal validity and reliability, it must be generalisable, objective and value free. On the other hand, to claim trustworthiness the research has to be conducted and presented in a manner that would allow the readers to trust the findings. The validity and trustworthiness of the study is considered in the next section.

5.9.1 Validity and Reliability

To ensure reliability and validity in research, so that the research can be used in practice (Noble and Smith, 2015; Nowell et al., 2017), the researcher needs to be sure that the research was implemented in a robust and rigorous manner. Two crucial elements in research which ensure quality are reliability and validity.

5.9.2 Reliability within the Methodology

The methodological quality of this research is evaluated in terms of reliability and validity. Reliability of the research in this study is about whether the methods and procedures used would produce consistent results if they were repeated or replicated in the future by the same or another researcher in a similar context and over similar samples (Bryman, 2016; Cohen et al., 2018). The concept and the role of reliability within the methodology is to specify the extent the research is free from error, especially in relation to the assessment instruments. That is, the more errors found in the instruments, the more unreliable the findings of the study would be. The idea was to reduce the measurement errors in the study. Generally, reliability within this study was initialised through the piloting of the research instruments. There was openness about the research procedures which were described extensively. Establishing trustworthiness, precision and accuracy of the measures in the research was important because certain errors can be a threat and influence the overall reliability of the overall findings. Reliability differs in meaning in quantitative and qualitative research. Reliability in the methods was enhanced using triangulation, where interviews and journals were used to study the same phenomenon, so that the shortcomings of one method is compensated for by using another (Bryman, 2016; Cohen et al., 2018).

In terms of the quantitative aspect of the research, and within a certain limit of experimental error or random error (Cohen et al., 2018), reliability in this study would mean stability, equivalence, and internal consistency in results if the same methods and research instruments are replicated with the same sample; as recorded in Table 6.5 for the control group which demonstrated both stability and equivalence of the test (Basit, 2010). This also means that replicability over time, using a similar sample and context, would produce similar results. Reliability of the MKT test result was achieved by crosschecking the data (see section 6.3.4). The internal reliability of the questionnaire survey was calculated resulting in an acceptable Cronbach's alpha coefficient which is high (Downing, 2004), (see section 6.4.1).

In terms of the qualitative aspect of the research there is little possibility of replication due to its subjectivity, distinctiveness in samples, and specific setting, and "does not seek duplication to claim reliability" (Basit, 2010:70). Reliability was, rather, ensured through the trustworthiness of the measures, accuracy, honesty, detail, and depth of response. That is, a fit between what I recorded as data and what occurs in the natural setting (Cohen et al., 2018). To limit the threat to reliability through participant biases, all interviews with the seventeen participants were conducted in favourable environmental conditions on different days and mostly in the morning, when participants were still fresh and felt free to speak their mind, in order to obtain accurate data. The participants were not encouraged to give expected answers. This was to limit both researcher error and interviewee bias. Consequently, the responses from the interviewees were consistent with one another and yet the participants were from different schools. To further limit researcher bias, I remained objective when making subjective interpretation of the participants' responses.

5.9.3 Credibility (Internal Validity) and Enhancement Strategies

Validity is the accuracy of the results in relation to what actually occurred, or it is a measure of reality (e.g. positivist stance), and it is sometimes referred to as internal validity. It is the extent to which the instrument measures what is it is supposed to measure (Punch and Oancea, 2014; Creswell et al., 2018). In this study, the researcher considered the following four procedures in order to establish the qualitative credibility, rigour and trustworthiness of the research process.

Spend Prolonged Time in the Field

Spending adequate time in the field has been recommended by several researchers (e.g. Lincoln and Guba, 1985). Spending more time in the field of study provides the researchers with a more in-depth understanding of the phenomenon being studied which, in turn, provides credibility to narrative accounts (Creswell, 2013). In this study, the researcher spent a prolonged time in the field in order to build more trust with the participants as well as to get accustomed to the research setting. This involved engaging with mathematics coordinators in the school.

Thick Description

Thick description through rich discussion is an effective way to give the readers a candid picture of the research field experience of a particular theme, in order for them to make their own judgments with regards to transferability. Tracy (2010:843) explains that it is "one of the most important means for achieving credibility in qualitative research". In this study, enough details were given to the readers so that they could grasp the true scenario, or setting being described.

Member Checks

Member checking or member validation is a form of error reduction which tests the accuracy or truthfulness of qualitative findings by taking the final report back to the participants to confirm the facts. Lincoln and Guba (1985) and Bailey (2018) aver that member checking is widely mentioned in the literature and is an important strategy for checking the credibility of qualitative studies, thus increasing their trustworthiness. In this study, after the data collection and transcribing of the interviews, the transcripts were shown to the participants to make sure they were accurate (Mears, 2017).

Triangulation

In social research, triangulation is the use of several methods (e.g. data sources, theories, researchers, methodologies) to investigate a phenomenon (Alexander, 2018; Bryman, 2016; Bailey, 2018; Cohen et al., 2018). Biesta (2017:159) defines it as seeking the "convergence and corroboration of results" using different methods and design within the same study. The aim is to crosscheck findings from the qualitative and quantitative methodologies, thus enhancing the validity and reliability of the study which may be compromised due to biases or deficiencies intrinsic to single-method study (Alexander, 2018). Triangulation was attempted in this study through the use of multiple data resources (e.g. interviews, survey questionnaires, tests and journals). Methodological triangulation (Flick, 2014) in its two forms (e.g. within-method and between-method) was employed to help improve the trustworthiness and validity of the study as well as to overcome paradigmatic biases. Triangulation was also achieved by using different methods for collecting the qualitative data. For example, due to the general deficiency of survey questionnaires (see Section 5.6.3), it was necessary to off-set this by conducting interviews as a form of between-method triangulation in order to determine the accuracy of the information from the teachers. Similarly, within-method triangulation was performed using interview and questionnaire as a mean of cross-checking the data (Cohen et. al., 2018). The established themes in the qualitative analysis were based on the converging of several data sources (Olson et al., 2016; Creswell et al., 2018), thus ensuring that the findings are credible and reliable. Also, the reporting of the case-study findings draws on multiple sources at different times to enlighten the phenomenon being studied (Flyvbjerg, 2011; Denzin and Lincoln, 2018); thus, implementing data triangulation. Also, data were collected using different methods; thus, implementing methodological triangulation.

5.9.4 Transferability and Generalisability

Transferability is when rich description is made of the data so that the reader can make comparisons with another defined setting or wider population beyond the current setting and situations. On the other hand, generalisability or external validity (Bailey, 2018), implies that the sample statistics can be applied to the population from which the same is drawn. In the writing up of the thesis, rich descriptions and contextual information of the fieldwork (Tracy, 2010) were provided using personal testimonies from the different cases so that the reader could see the boundary of the study and identify the possibility of transfer.

5.9.5 Credibility and Dependability of the Interviews

Miles et al. (2014) report that the study participants are the key players in determining whether the results of the study accurately represent their experiences, thus rendering your research to be credible or not. Based on such a contention, the credibility of the interview protocol in this study was upheld by using questions that guided the participants to talk about issues that helped to understand their lives and experiences. Also, an audio recorder was used to record the interviews.

5.9.6 Reliability and Validity of the Tests

The researcher was aware that the teachers' test, which was designed and developed specifically for the study, had to be validated. The validity of tests is the extent to which they measure what they are intended to measure. To enhance the validity and reliability of the test, a mathematics education teacher at SITE, with degree in mathematics education, independently checked the appropriateness and relevance of each question in order to ensure content validity, as well as providing her expert opinions. It was agreed that some questions had to be modified because they were slightly above the knowledge reach of the teachers. A time difference of eleven weeks was kept between the administering of the pre- and post-test, not just for the intervention to take effect, but also to minimise the memory effect of the test-retest.

5.9.7 Reliability and Validity of the Questionnaires

Another instrument that produced quantitative data was the questionnaire. The validity question for the questionnaire was whether it was measuring what it was meant to measure. Similarly, the questionnaires were piloted to ensure the validity and reliability of the instrument.

5.9.8 Internal Validity and External Validity of the Quasi-experimental Design

One of the methodological challenges of the quasi-experiment is the threat to internal and external validity (Handley et al., 2018). Any reader of the thesis would have the right to ask questions such as: Are the findings sound and conclusions correctly made? Is the intervention solely responsible for the change? Due to the absence of random assignments, quasi-experiments fall prey to these threats. The internal validity of an experiment is the ability to acknowledge that the intervention was the sole cause of change. Joyner et al. (2013) explain internal validity as "the extent to which the researcher could claim that it is the independent variable that caused the dependent variable". The internal validity of the quasi-experimental design can be increased through the elimination of extraneous variables. Extraneous variables are variables that enter the experiment and interact with the independent variable(s), thus affecting the dependent variable(s). For example, in this study the effects of emotional warmth and affection of the teachers can work together and interact with the independent variable (e.g. RP). In order to ensure consistency of conditions, all the subjects in the experimental and controls groups were exposed to the same conditions apart from the intervention of the experimental group.

Threat to internal validity was dealt with in the analysis using the Difference in Differences (DiD) methodology. DiD was the analytical approach used to capture the differences of MKT gain across the control and intervention groups that are constant over time (see Section 6.3.6). The DiD estimator compensates for one important limitation of the t-test, which is not being able to control environmental effects on the groups. Recently, Lavrijsen and Nicaise (2016) from Belgium used the DiD approach to examine the effects of the age at which tracking occurs on pupils' achievement using assessment data from PISA, TIMSS, and PIRLS. They used DiD to control secondary school results from confounding variables (i.e. tracking) already present in primary schools. DiD makes the parallel trends assumption (Lechner, 2011) that ensures internal validity of the DiD model (see Figure 6.2). That is, everything else that is time variant must be affecting both groups in the same way. For example, Figure 6.2 shows that before the intervention, both groups were following similar trend lines. Then, the intervention group was exposed to RP and put on a new trend line, otherwise, both groups would have continued on similar trend lines. The trend lines assumption is supported by the t-test results (see Appendix 21) which show failure to reach statistical significance between the two groups at pre-intervention time. The DiD methodology uses the change in the difference between the control and intervention group after the intervention (e.g. RP) and produces an unbiased estimate of the intervention effect. DiD was used because it focuses on the change only, and thus dismisses any time invariant factors which could have confounded the effects of the intervention.

5.9.9 Reflexivity

In order to manage the threat to trustworthiness in qualitative research, I need to address the issue of reflexivity. Personal reflexivity in research is about reflecting on my role as the researcher in the research (King, Horrocks and Brooks, 2019). One important reason is that the meaning of reality is co-constructed by both the participants and me, which can have detrimental effects on the production of data in this study. My role in the field research is important and should be explained, as this could have profound effects on the way the research is interpreted. Reflexivity is also a way of enhancing the rigor of the research process by being “aware, open, and forthcoming” in order to augment credibility and trustworthiness to qualitative research” (Lichtman, 2013:158). Reflexivity is a concern in interpretative research because of the inherent subjectivity of the qualitative researchers; and they have to ensure objectivity throughout the research process so that the interpretation of the data is not readily clouded. Objectively, I was aware of my influences, such as “biases, values, gender, history, culture and socioeconomic status” (Creswell et al., 2018:183), on the research process which could threaten the validity of the study. In terms of status, I am an ex-employee of the MOE, and an ex-teacher trainer at SITE. I am aware that such status may have facilitated my access to the schools and the teachers. Hence, these may have, in one way or another, influenced the responses towards the study. Therefore, being aware of these threats, I have to step back and reflect on their role in the study; on how their self-characteristics could shape the direction of the study. As part of the reflexive process and being aware of its challenges, I was sensitive to the fact that I may have helped to shape the data. Hence, I tried to maintain a delicate balance between distancing myself as much as possible from the study, in order to ensure objectivity, but at the same time partially involving myself with the participants so as not to miss out on important field insights. I ensured that permissions were obtained from all the case schools as well as obtaining the participants’ informed consent. It would not have been truthful to state that it had been possible to remain totally objective throughout the fieldwork. This would have meant being able to detach oneself from one’s values, personality, and character as a researcher, which is not possible. Therefore, as part of the reflexive process, it is more appropriate to acknowledge any inherent biases, rather than try to avoid them. The partial involvement with the participants was important in dealing with biases, personal values, which could have influenced the field data. Also, the involvement was useful in terms of being able to connect with the participants during the fieldwork, to be able to further fine tune some data collecting questions. As part of the reflective process in the semi-structured interview, I tried to maintain a good rapport, build an atmosphere of trust, and an assurance of confidentiality with the participants. I made the participants feel relaxed by chatting to them at the start of the interview, so that they could feel at ease. This also made them aware that I was genuinely interested in what they had to contribute to the study.

5.10 Data Collection Procedure for the Main Study

This section describes the data selection methods for the main study. The tools, participants and sample size are introduced together with their respective data collection methods.

5.10.1 The Gaining Entrée

After obtaining ethical approval from Staffordshire University (UK) (see Appendix 6), the researcher was ready to start the data collection by gaining access to the research settings and subjects, or 'gaining entrée'. Complexities of gaining entrée can greatly affect the types of data and information collected by the researcher. Permission and formal approval to conduct the study in the primary schools had already been given to the researcher by the Ministry of Education in Seychelles (see Appendix 7) following a letter which was written to them (see Appendix 8). There was no challenge in getting access to the research sites (e.g. the schools). However, there were some challenges in recruiting the participants once the sample was defined. As an initial contact with the schools, the researcher met with the head teachers in October 2018 and discussed the research in terms of ethical issues, and what would be required throughout the study. The head teachers were also given relevant copies of documents relating to the study. All the head teachers expressed a strong interest in the study and were pleased for their schools to be on board. During that same introductory visit, the researcher distributed copies of the information sheet and consent form to all the potential participants. After the researcher got the consent of the participants, a session was organised with all the participants at which they were introduced to the study. They also engaged in a professional development session organised by the researcher. In terms of time spent in the field, the research design required that a twelve-week period was needed to collect the data. However, due to the end-of-term examinations, the study was conducted in a time frame of ten weeks. The data collection started in October 2018 and ended in May 2019.

5.10.2 Dataset and Sampling

Seychelles had twenty-four primary schools with a current teacher population of 582 at the time of the study. In terms of the sampling method for the quantitative element of the study, it was important to ensure that the sample was representative of the population and of an adequate size (Cohen et al., 2018). According to Cohen et al. (2018), a population of 120 (24x5) primary mathematics teachers would have required an approximate sample size of ninety-one teachers, at a 95% confidence interval and confidence level of 5%. That is, for this study a random sample size of ninety-one teacher participants would have been required. However, it was not possible to obtain such a sample size (n=91) in this study because not all the teachers were willing to take part. Some of the reasons given were that the intervention study would take too much of their time; others found it too intensive.

However, when discussing this issue with both other participants and non-participants, it was revealed that some teachers had refused to participate because they saw that one of the tools was assessment of their MKT, and they seemed to see this as a treat. Consequently, the researcher had to consider schools where the teachers willingly gave consent to the study. The schools for the study were chosen based on their location on the Island, in order to get a good representative sample of teachers. Thirteen schools agreed to take part in the study. Each one of those primary schools had an average of four to five mathematics teachers. Hence, for the quantitative part of the study, a sample size of (n=58) primary mathematics teachers who were willing to take part was taken from a population of (N=120). Because the sample size for the quantitative part of the study is below (n=91), the results derived from some of the statistical analyses (e.g. t-tests) need to be interpreted cautiously. However, the sample size met the requirements of several statistical analyses, such as correlation analysis and some experimental methodologies which require a sample size of not less than thirty (Cohen et al., 2018). Figure 5.1 in Appendix 9 shows the samples of the participants in the study. In conclusion, a total of fifty-eight primary mathematics teachers (fifty-seven females and one male) took part in the study and provided the full sample for the study. Other subsequent samples were derived from this full sample. It can be seen from Figure 5.1 that there were more teachers in the control group than the experimental group. This was because some of the teachers had concerns about the writing of journals, and therefore preferred to opt for the control group, which did not have to write journals.

The main criteria for inclusion in this study was that participants should be currently teaching primary school mathematics in a government primary school in Seychelles. The participants from most schools were selected according to teaching level by the mathematics coordinators and the researcher using purposive sampling strategies; while in other schools the selection process was based on the availability, and commitments of the teachers (e.g. convenience sampling). Purposive sampling was used to ensure the presence of different teachers in the study (Mason, 2018; Cohen et al., 2018). The sample (n=58) for the main study was then divided into the experimental group (n=17) and the control group (n=41), making sub-groups of at least thirty participants which were needed for a valid inferential statistical analysis.

5.10.3 Main Study Research Instruments

The methods used to collect data for the main study comprised of quantitative instruments, which were questionnaires, and tests, and qualitative instruments which were journals and interviews. Figure 5.2 (see Appendix 10) presents an overview of the study phases, showing the four phases of the main study and their respective methods. In the main study the instruments were administered in this order: pre-test, pre-intervention questionnaire, reflective journal guide, interviews, post-test, and post-questionnaire. The next section describes the rationale, the participants, and the procedures used to implement the research instruments**.**

Pre-intervention Questionnaire Administration

The survey was designed to gauge the teachers' self-perceived levels of their MKT and sub-domains, and self-efficacy beliefs. The pre-questionnaires (see Appendix 11) were administered initially to (n=58) teachers teaching at different levels in the primary schools. These were the fifty-eight teachers who gave their consent to take part in the study and completed the pre-questionnaires. It took an average of 20 minutes to complete the questionnaires. The returned pre-questionnaires had a response rate of 100%.

Pre-intervention Test

At the outset of the intervention stage, pre-tests were administered to both the experimental and control groups of teachers prior to the intervention in order to assess their MKT level. The tests were invigilated by the researcher. Fifty-eight (n=58) teachers consented and sat the pre-intervention test.

Professional Development Session for the Intervention

The intervention was preceded by a content focused (Desimone, 2009) professional development (PD) session where the participants were introduced to the research and trained by the researcher in using the PIES strategy, and in journal writing. The control groups were trained in using the PIES mnemonic strategy only. The intervention groups were trained to use the PIES mnemonic strategy to teach arithmetic word problem solving strategies, and journal writing using Gibbs' (1988) reflective cycle model. The researcher explained how they could integrate the PIES strategy into their current lesson structure, and they also discussed examples of reflective journals using Gibbs' (1988) model. The role of critical incidents in reflection and learning from experience were pointed out to the participants (Erdem Mete, 2019). The intervention phase was the RP implementation which consisted of a ten-week session where the experimental and control groups taught arithmetic word problem solving tasks to their pupils using the PIES strategy, but the control group did not reflect on their practices. The intervention study was implemented during the months of January to April 2019. A sufficient length of time was required for the intervention to take effect on the participants. The ten-week intervention was designed to investigate the implementation of RP while using the PIES strategy to teach pupils word problem solving strategies. The researcher provided support, guidance, and monitored the participants during the intervention. The study was conducted in four distinct phases depicted in Table 5.2.

Table 5.2: The phases and timeline of the study

Phase	Content	Timeline
Phase 1	**Preliminary** • RP and journal writing workshop	June 2018
Phase 2	**Pre-intervention** • Pre-questionnaire • Pre-test	October 2018
Phase 3	**Intervention** • PIES strategy • Reflective practice treatment • Reflective writing	January 2019 to April 2019
Phase 4	**Post intervention** • Post-questionnaire • Post-test • Interviews • Reflective journal	April 2019

The participants were either allocated to the intervention or the control group. Eventually, there were forty-one participants in the control group and seventeen in the intervention group as shown in Table 5.3.

Table 5.3: The Intervention model

Group	Pre-Test	Treatment	Post-Test
Control Group (n=41)	Yes	No	Yes
Intervention Group (n=17)	Yes	Yes	Yes

All mathematics lessons given by the teachers in the intervention group were followed by post-lesson reflections which were recorded in their reflective journals. Weekly reflective journals were collected from the participants as further sources of data. During the implementation phase, the researcher made random classroom visits to both the intervention and control group participants to monitor their progress. The post-intervention phase comprised of the administration of post-tests, post-questionnaires, and semi-structured interviews. The pre-test was administered as a post-test to both groups one week after the intervention in order to examine the RP effects on their MKT. In-depth, semi-structured interviews were conducted with the seventeen participants from the intervention group to obtain their perceptions of the effects of RP on their MKT sub-domains and self-efficacy. Braun and Clark (2013) recommend a sample size of fifteen to thirty individual interviews in qualitative research in order to start seeing patterns in the data. Also, the post-questionnaires were administered to all the participants.

Conducting Post-intervention Interviews

In each case school, semi-structured interviews were used to gather the subjective experiences, perceptions, and beliefs of the participants about their MKT and self-efficacy pertaining to the teaching of arithmetic word problems solving. (Percy, Kostere and Kostere, 2015). This aimed to unpack the survey questions in more detail. To ensure continuity, all the participants were asked the same set of open-ended questions (Dawson, 2009), but during the interviews some prompts were different depending on the answer provided by the interviewee. Before the interviews, the interviewees were reminded of the purpose of the interview, about confidentiality, the intended duration (30-45 minutes), and their permission was sought for them to be recorded. The researcher used an interview protocol to guide the interviews towards the research questions. The questions used in the interviews were based on the literature of MKT, RP, and word problems. The interviews were meant to answer Research Questions 1 and 3.

RQ1. To what extent do the MKT sub-domains and MKT self-efficacy beliefs of primary teachers develop after engaging in reflective practice?

RQ3. To what extent does the MTSE level of primary teachers change after engaging in reflective practice?

The interviews were audio recorded as recommended in the literature (Rabionet, 2011), using a high-quality Sony ICD-PX440 digital audio recorder, and saved in MP3 format. During the interviews the researcher took official field notes, which included a summary of his reaction towards the interviews (King, Horrocks and Brooks, 2019). In some cases, the researcher used visual aids in the interviews (Gibbs' (1988) reflective model) to generate discussion around RP questions. The interviews were transcribed just after the field work, and member checks were applied (Patton, 2015**)**.

Transcribing the Interviews

All the interviews were transcribed verbatim. Full, verbatim, orthographic transcription was necessary because the researcher wanted to make an in-depth examination of the participants' experiences. Copies of the transcripts were given to the participants to verify their authenticity. The verbatim transcriptions were used for textual analysis in NVivo, and the task was, therefore, to transcribe the recordings as accurately as possible. All the interviews were conducted in English to avoid issues of translation which also facilitated the task of transcribing. All transcripts were saved together with other research data on the researcher's home PC using a password. They formed part of the case-study database which was maintained throughout the data collection process (Yin, 2018:130-134), thus adhering to the reliability and validity requirements of the data collection.

Post-intervention Test

After the intervention, post-tests were administered to both the intervention and control groups by the researcher. Forty-eight (n=48) participants consented and sat the post-intervention tests. The researcher corrected the tests and recorded the scores of the MKT level of the participants for both groups.

Post-intervention Questionnaire Administration

At the end of the ten-week intervention period, the post-questionnaires were administered to both the control and intervention groups by the researcher. Fifty (n=50) teachers consented and completed the post-questionnaires. The returned post-questionnaires had a response rate of 86% (e.g. 50/58).

5.10.4 Fieldnotes

The researcher made written accounts of what was heard, seen, and experienced over the course of the data collection process. Bailey (2018) explains that the major purpose of field notes is to have a detailed account of the researcher's observations and interactions in the field which can be used to conduct a rigorous analysis. The fieldnotes were used as a device which helped to understand the research settings and to test out the teachers' 'analytical ideas' (Mason, 2018). Without fieldnotes the researcher would have forgotten many of the details of the field work. For example, a significant event during the data collection phase happened when the researcher went to one case school to collect the pre-tests and pre-questionnaires and was faced with the school refusing to take part in the study, even though they had initially agreed and given their consent to do so. They claimed to be busy with other school tasks. However, it was later revealed that the teachers at the school were wary of the MKT test, which was inextricably linked to the poor mathematical performance of pupils in that school.

Patterns in the fieldnotes were examined in comparison with themes identified from the collected data. A significant observation made by the researcher during the study was that the culture of teachers conducting action research in schools has quickly eroded, and teachers in general could not make logical connections between classroom research and every-day classroom practices.

5.11 Data Analysis Procedures

Castleberry and Nolen (2018) explain that it is imperative for researchers to report on the design of their studies, so that high educational scholarship is maintained, as well as building trustworthiness and credibility with their readers. Data analysis is a very important phase in research (Maguire et al., 2017). Therefore, it is important that the analysis procedures are effectively presented and discussed. Hatch (2002, cited in Bailey, 2018:160) defines analysis as: “organising and interpreting data in ways that allow the researcher to see patterns, identify themes, discover relationships, develop explanations, make interpretations, mount critiques, or generate theories”. The analysis of the data was underpinned by an interpretivist paradigm and involved a mixed methodology. The qualitative methods were meant to obtain the participants’ experiences of their RPs. The qualitative data analysis consisted of analysing data from the reflective journals, semi-structured interviews, and open-ended survey questions while the quantitative data analysis consisted of analysing data from tests and questionnaires. Based on the convergent mixed-methods approach, both qualitative and quantitative analyses were concurrently conducted, merged, and then interpreted (Creswell and Plano Clark, 2011; Creswell et al., 2018). Although this research took a mixed-methods approach, it remained focused on the adopted pragmatic and interpretive position in conducting the overall analysis of the data.

5.11.1 Quantitative Data Analysis

The quantitative data sought to provide empirical evidence related to the qualitative data regarding any change in the participants’ practices. The quantitative data from the tests and survey were subjected to analysis using the IBM Statistical Package for Social Science (IBM SPSS ver.25). Descriptive statistics, inferential statistics, and the Difference in Differences (DiD) estimator were applied to the data analysis. Numerical measures were necessary to establish the extent of the changes caused by the RP intervention. Firstly, this was needed to compute and interpret the changes in the MKT and self-efficacy score of the participants descriptively and inferentially. Secondly, it provided a statistical analysis of the self-perceived level of the participants of their MKT. The data were cleaned, coded, and then entered into the SPSS software. The following statistical tests were applied to the data. Firstly, t-tests were applied to check for significant differences between the mean of the control and experimental groups before the intervention. Levene’s test was used to compare the pre-test groups mean to ensure that there was no statistically significant difference in their MKT following the pre-tests. The Kolmogorov-Smirnov test (K-S test) was used to check for normality in both samples. Independent t-tests were used to compare the difference between the pre- and post-means. Difference in Differences (DiD) methodology was used to calculate the unbiased differences in the means; and cluster analysis was used to group the participants.

5.11.2 Qualitative Data Analysis

Qualitative data analysis was the process that enabled the research to reveal themes that could help to answer the research questions. Miles et al. (2014:10) explain that one of the features of qualitative data is that “they focus on naturally occurring, ordinary events in natural settings”, and provide a powerful picture of real life. In this study, the qualitative data are in the form of interview transcripts, audio recordings, journals, and fieldnotes. The object of qualitative data analysis is to get a complete understanding of data in order to answer the research questions (Merriam, 2009; Savin-Baden and Major, 2013). The next section discusses the types of content analysis techniques that have been adopted to analyse the qualitative data in this study.

Thematic Analytical Approach

In this research, inductive and deductive thematic analytical approaches were applied to the analysis of the qualitative data (Nowell et al., 2017), where the researcher started manipulating a smaller data set and then moved from there to uncover “the larger picture that emerges” (Savin-Baden and Major, 2013:435). According to Braun and Clarke (2013:175), thematic analysis is an approach used to “identify themes and patterns across a dataset, in relation to a research question”, and is widely used in various methods of qualitative analysis such as grounded theory and discourse analysis (Braun and Clarke, 2013; Javadi and Zarea, 2016; King et al., 2019). Thematic analysis was chosen because the literature reveals that it is an easy-to-use approach for beginning qualitative researchers, flexible, and appropriate for comparing and contrasting the views of the different participants (e.g. Braun and Clarke, 2006; Savin-Baden and Major, 2013; Cohen et al., 2013). Thematic analysis was also chosen for its compatibility with the chosen constructionist and the adult-learning theoretical frameworks, the theoretical perspective and the interpretive paradigm underpinning this study. The researcher applied both manual and electronic coding on the data. Even if manual analysis (coding) was more time consuming, the researcher thought that it would provide a deeper understanding of the collected data (Basit, 2003). The research broke down the data into codes, categories, patterns, and themes, in order to draw conclusions. In this research, codes were meaningful names and short phrases representing ideas in the transcripts and text in order to capture the essence of the data (Miles et al., 2014). The production of the codes was data driven as opposed to theory driven. The data were coded and assessed using open, axial, and selective codes as part of the data-reduction phase. However, both types of coding approaches require the researcher to do the analysis. During the coding process the researcher ensured that the essence of the data was retained. The process was cyclic and iterative. Individual cases were analysed inductively and deductively for emerging themes and patterns and compared across all cases (Miles et al., 2014). The approach of the inductive coding was to ensure that predefined codes do not obscure the identification of new concepts and theories. On the other hand, the use of the deductive approach, that is, the use of theoretical and predetermined codes, was to ensure that explicit theoretical themes are used to capture the essence of the text (Basit, 2010). This study involves an inductive and iterative process of basic thematic data analysis which followed phases (see Appendix 13, Table 5.4) adapted from Braun and Clarke, (2013). The table depicts the thematic analysis phase, its description, and the means or criteria of establishing trustworthiness. Even if the above framework is linear, the thematic analysis of the data was not a linear process, but rather recursive. The researcher went back and forth between the collection, analysis, and interpretation of data. The researcher applied the adaptation of Braun and Clarke's (2013) thematic data analysis to analyse the qualitative data.

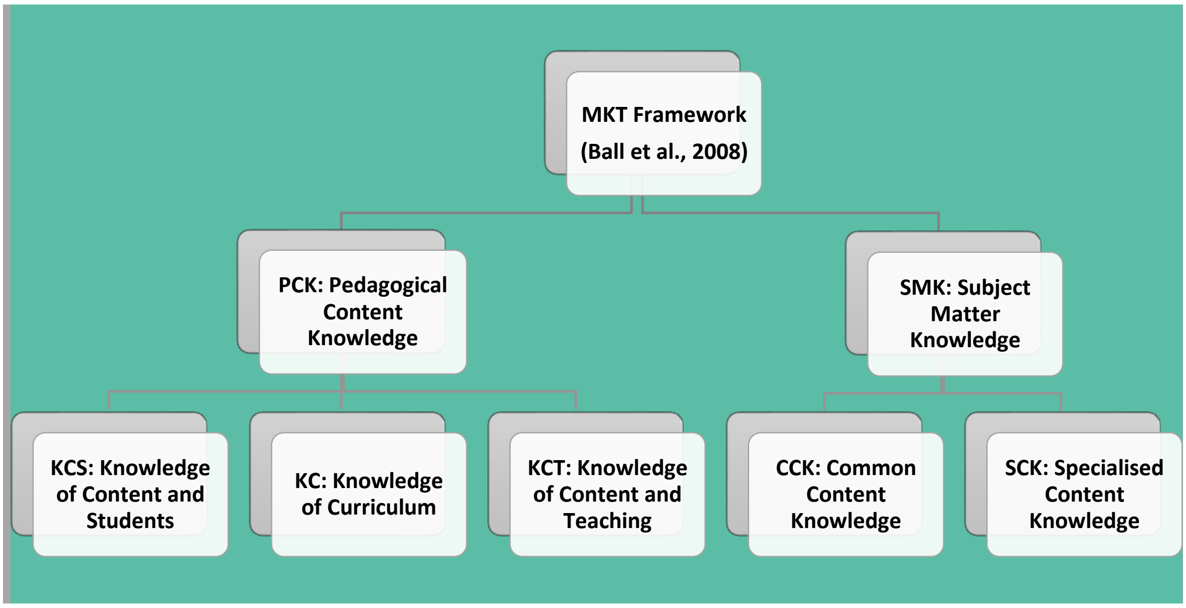
5.11.3 Codebook Development

A codebook was used to organise all the deductive codes and their respective definitions. This was necessary for consistency and reference when coding the entire qualitative dataset. Table 5.5 is an extract from the codebook, where deductive (*priori*) codes were used to code the type of mathematical knowledge manifested in the content of the data set (see Appendix 14). For example, each time a participant referred to predicting and interpreting pupils' thinking, or pre-conceiving their conception or misconception, these were coded as 'knowledge of content and pupil' (Ball et al., 2008). Before the categories and sub-categories could be gathered and the overarching themes built from them, several 'passes' were made at the data. This involved re-reading the interview transcripts, reflective journals and, at some point, going back to the interview recordings. NVivo 12 was very effective in managing the data, especially when it came to the handling of hierarchy nodes and frequency of codes. The final categories and sub-categories were a mixture of descriptive, process, and In Vivo coding (Miles et al., 2014). However, much of the qualitative analysis in the end was conducted manually using Microsoft Excel spreadsheet software. After the completion of the coding, the frequencies of the coding were calculated and then converted to percentages.

5.12 Data Analysis and the Analytical Framework

In terms of the deductive approach, or framework-driven thematic analysis, sub-domains from Ball et al.'s (2008) MKT framework (see Section 3.3.1) were used as *a priori* categories. That is, the emergent categories were mapped to the *a priori* theoretical domains MKT framework, which consists of six knowledge types for the effective teaching of primary mathematics. Miles et al. (2014) suggest that an existing theoretical framework can be used to elicit *a priori* categories. On the other hand, for the inductive, open-coding, and theory-driven approach, *a posterori* codes or emergent categories were connected to the evolving MKT framework in order to answer the overarching research questions and forward new theory. Ball et al.'s (2008) MKT framework (see Figure 3.1) was used both as a deductive coding and analytical framework in the analysis of the qualitative data.

Figure 5.3: Mathematical knowledge framework (Ball et al., 2008) [adapted]



Ball et al.'s (2008) MKT framework was adapted for this study. The framework is made up of six core sub-domains or six types of knowledge to teach primary mathematics. The "knowledge at the horizontal" which is about how past, current, and future mathematics topics are connected, was not considered in this study. In this study, the MKT framework is used as a guideline and does not restrict the interpretation of the data. Each of the qualitative sets of data in this study (e.g. teachers' interviews, reflective journals and open-ended responses) was analysed to determine the aspects of MKT emphasised in their content by the participants. The data were scrutinised for five aspects, or five MKT sub-domains as depicted in Figure 5.3. Evidence from the pilot study suggested that "forward-looking horizon activities" by primary mathematics teachers are very minimal or implicitly used by the teacher.

5.12.1 Analysis of the Interview Data

King et al. (2019:192) explain that when it comes to the analysis of interview data, a distinction is made between approaches that are strongly focused on the language used by the participants and those that focus more on what the participants have to say. The latter approach comes from the "contextualist or realist philosophical positions" and includes research approaches such as phenomenology, grounded theory and mixed-method case studies. Such an approach allows the researcher to 'walk' and 'live' the experience of the participants in this study. The interviews were analysed using inductive and deductive thematic analysis. For both the deductive and inductive thematic coding, the text was checked against the components and aspects of MKT and self-efficacy for themes and categories. The researcher started with deductive coding using *a priori* codes from the MKT literature, more precisely Ball et al.'s (2008) MKT model. A list of codes with definitions and examples was compiled (see Table 5.5 in Appendix 14).

5.12.2 Analysis of the Reflective Journals

The reflective journals were analysed inductively and deductively. Fifty-two (n=52) reflective journals with an average of three from each case-study participant were transcribed and coded in NVivo 12. They were then analysed by the researcher, employing a thematic approach. When analysing the reflective journals, the researcher examined the changes in the MKT and self-efficacy beliefs in the participants' reflections pertaining to the teaching of arithmetic word problem solving strategies. Excerpts from the journals were used to describe a particular elicitation in the content of their reflections.

5.12.3 Mixed-methods Analysis and Integration

Creswell and Creswell (2018) explain that data analysis in mixed-method convergent design consists of three main phases. In this study, the quantitative data were first analysed. Then, the qualitative data were analysed and collapsed into themes and broad categories. Later, the mixed-methods analysis was implemented where the qualitative and quantitative data were integrated. The data integration allowed the researcher to interpret the main findings. That is, findings from the qualitative analysis were compared and integrated with the quantitative results at the reporting level using the weaving approach (Wium and Louw, 2018). When integrating the qualitative and quantitative data, the researcher searched for convergence, divergence, contradictions, and relationships between the two sets of data (Creswell and Plano Clark, 2011). The findings were then interpreted. The interpretation involved discussions by comparing results and findings from the quantitative and qualitative data, taking note when there is 'convergence or divergence' between the two data sources (Creswell and Creswell, 2018:221). The researcher triangulated the methods by comparing the qualitative findings with the quantitative results.

5.12.4 Computerising the Analysis of the Qualitative Data

From the researcher's personal experience, NVivo was only partly used because it was not desirable and effective to conduct qualitative data management on a large data set using only the manual coding method, even if it was possible. One marked disadvantage of manual coding of qualitative data is that it can be messy, and time consuming. However, the researcher did not rely totally on the analytical software. Computerised coding was conducted alongside the pencil and paper coding methodology and analysis

(Kelle, 1997), as it was important to understand that this is not the medium of analysis that ensures the rigour of the analysis, but rather the researcher (Barbour, 2008). However, the use of NVivo has provided significant advantages to the analysis which would not have been possible with the manual coding (i.e. searching for frequency of terms used by the participants), which gave a whole different depth to the coding of the text. Moreover, as a beginning researcher it is important to be able to use computerised data-analysis software.

5.13 Ethical Considerations

Research ethics with roots in medical research (Wiles, 2013) are the norms that guide the behaviour of researchers, so the participants are not hurt in any way (Basit, 2010; Hammersley, 2017). It is expedient that the researcher adheres to the ethical principles in order to provide validity and integrity to the research findings (Creswell et al., 2018). Also, to conduct the research within an ethic of respect for the “person, knowledge, democratic values, quality of educational research and academic freedom” as advised by the British Educational Research Association (BERA, 2018). The various ethical issues raised by most research studies irrespective of methodologies prior, during and after the study, briefly include access to the sample, informed consent of the participants, privacy of participants, anonymity of participants, confidentiality of participants, avoiding harm to participants, and deception (Cohen et al., 2018; Creswell et al., 2018; Israel, 2015; Brooks et al., 2014; Basit, 2010). These are the cornerstones of ethical conduct. The fact that most educational research interacts with human participants, most of the aforementioned ethical principles were significant and relevant to this research. Ethical issues were considered at all stages of this study in order to assess the risk to the participants. At the outset, permission was sought and obtained from the MOE in Seychelles to conduct research in the state primary schools. Similarly, permission and ethical clearance, which were paramount to the study, were sought and obtained from Staffordshire University’s ethics committee. From the start, the researcher informed the participants of what was expected of them, and that they would be required to complete several research instruments (see Appendix 15). To avoid any misunderstanding between the participants and the researcher, the informed consent documents were presented in a way that was well understood by the participants and supported by a verbal explanation about the purpose of the study as well as the participants’ role (see Appendix 16). The participants who agreed to take part in the study were requested to sign an informed consent form (Brooks et al., 2014; Israel, 2015; BERA, 2018; King, Horrocks and Brooks, 2019) before the data collection took place. Questioning teachers about their self-efficacy beliefs and teaching approaches is quite a sensitive process from a professional standpoint. With this awareness, the researcher was cautious when drawing out sensitive information from the participants. Equally important was that no harm befell the participants and pupils during the data collection phase. Anonymity and confidentiality were also addressed. The anonymity was maintained by providing the participants with a unique identification number which was used throughout the study. Pseudonyms were used to protect the names of the institutions and the participants, even if participants wanted to waive anonymity. Participants and schools who withdrew from the study, were not penalised. The utmost care and caution were taken when using the research instruments. Manual data files (e.g. interview transcripts, questionnaires, field notes) were stored in locked cabinets in a secure location and the real names of the participants were stored in a separate location at the researcher's home. To conform to the ethical guidelines for the data analysis (Brooks et al., 2014; BERA, 2018), and to ensure that the study was trustworthy, the thesis reported the details of data collection, instrumentation and analysis in terms of validity, reliability, transparency and generalisation (MacNaughton et al., 2020). No reciprocity was offered to the participants in this study, and all participants in the study were treated equitably. The ethical issues were considered throughout the entirety of the research. Additionally, ethics were also considered in the analysis and writing up of the research (Kara, 2015). In the analysis, the researcher ensured that the data were neither invented nor distorted, and the statistical techniques were used ethically. In the writing up of the thesis, it was ensured that the data from the participants were represented accurately and fairly.

5.14 Chapter Summary

This chapter has explained the methodology and methods that were used in this cross-sectional, quasi-experimental study of the effects of RP on the MKT and self-efficacy beliefs of primary school teachers in Seychelles. The study employed a mixed methodology by integrating quasi-experimental and inductive designs. In this chapter, the philosophical and theoretical assumptions and research design pertaining to the study were presented and rationalised. Using a case-study methodology, this research sought to locate, understand, describe the features of, and evaluate the evidence of the intervention that resulted in change in the MKT and self-efficacy of the in-service teachers. The data collection methods comprised of semi-structured interviews, journals, survey questionnaire and tests. The experiment compared the differences in performance of the intervention and control group teachers on a designed pre-post MKT test and questionnaires. The quantitative data from the tests and questionnaires supplemented the qualitative data from the interviews and reflective journals. The chapter also explained the procedures which were used to ensure the validity and reliability of the data so that the findings could be accepted as credible and trustworthy. The issues of reflexivity and research ethics in qualitative studies were also addressed. The chapter also made important points about the data that was to be processed and analysed for example, how the researcher went about analysing the data, and provided clarity around the processes and methods. The next chapter presents the results obtained with those methods.

Chapter 6: Quantitative Data Analysis and Results

6.1 Introduction and Overview of the Chapter

The previous chapter presented the methodology of the research. This chapter presents the quantitative part of the quasi-experimental study in terms of analysis and results of the effects of reflective practice (RP) on the MKT sub-domains, MKT self-efficacy and mathematics teaching self-efficacy (MTSE) of teachers pertaining to the teaching of arithmetic word problem solving. This chapter is devoted to presenting the key results of this study in relation to the research questions and hypotheses (Basit, 2010). Fundamental to this chapter is the analysis of the results and analysis of the pre- and post-intervention tests and pre- and post-intervention questionnaires to identify differences which may be accredited to the intervention. Both the educational and statistical significance of the intervention are examined. The educational significance is hypothesised to show enhancement in the MKT and self-efficacy of the teachers after the intervention. The statistical significance is to show that any enhancement is not due to chance, but by a specific change in the participants, that was tested. Importantly, the fact that this study is analysed within an interpretive paradigm, the results and their statistical significance from this quantitative analysis chapter are not for generalisation, but rather to support and explain events from the qualitative analysis in Chapter 7.

The chapter is comprised of seven major sections. Section 6.1 introduces the chapter and outlines the research questions and the hypotheses. Section 6.2 presents the demographics of the participants. This is then followed by Section 6.3 which presents the intervention effects of RP on MKT sub-domains. Section 6.4 presents the intervention effects of RP on MKT self-efficacy. Section 6.5 presents the intervention effects of RP on MTSE. Section 6.6 presents the cluster analysis for the grouping of the participants. Section 6.7 presents the summary of this chapter.

6.1.1 Research Questions

This chapter presents the quantitative analysis and results to answer the following research questions:

RQ2. Is there a statistically significant difference between the MKT sub-domain scores of the intervention and control groups after engaging in RP?

RQ4. Is there a statistically significant difference between the MKT self-efficacy beliefs of the intervention and control groups after engaging in RP?

RQ5. Is there a statistically significant difference between the MTSE of the intervention and control groups after engaging in RP?

6.1.2 Research Hypotheses

The alpha level used to test the level of significance throughout the study is 0.05. For Research Questions 2, 4, and 5, the following null hypotheses were developed:

$H_0$2: There is no statistically significant difference in the gain scores of MKT between the intervention group and the control group after engaging in RP.

$H_0$4: There is no statistically significant difference in the level of MKT self-efficacy beliefs between the intervention group and the control group after engaging in RP.

$H_0$5: There is no statistically significant difference between the MTSE level of the intervention and control group after engaging in RP.

6.2 Who are the Participants?

The setting for this study is Seychelles, and the sample is drawn from a population of primary mathematics teachers. Table 6.1 summarises their characteristics using data obtained from the survey questionnaire. The table is also quite revealing in several ways. It shows that out of the fifty-eight (N = 58) participant teachers who gave their consent, fifty-seven teachers or 98 % of the sample (n = 57) were female and 2% (n = 1) were male. Such gender imbalance is discussed in section 2.5. The control group profile were all female participants and the intervention group included one male. The participants belonged to the mean age group of 36-45.

Table 6.1: Demographics of the participants

Items and Percentages	
Gender	**Age Range**
F (n=57) (98%)	18-25 (16%)
M (n=1) (2%)	26-35 (45%)
	36-45 (26%)
	46-55 (12%)
	More than 55 (2%)
	Mean = 2.4 *~36-45*
Teaching Qualification	**Years of Teaching**
Untrained (13.8%)	Less than 1 yr. (10.3%)
Certificated (5.2%)	1-5 yrs. (22.4%)
Diploma (67.2%)	6-10 yrs. (20.7%)
Bachelor's degree (13.8%)	11-15 yrs. (17.2%)

	16-20 yrs. (13.8%) More than 20 yrs. (15.5%) ***Mean = 3.48 ~11-15 yrs.***
Mathematics Qualification	**Mathematics Teaching Experience**
None (7%) IGCSE core or equivalent (63%) IGCSE extended or equivalent (19%) O level (11%)	Less than 1 yr. (0%) 1-5 yrs. (27%) 6-10 yrs. (25%) 11-15 yrs. (18%) 16-20 yrs. (12%) More than 20 yrs. (18%)

The data from the table indicates that most of the teachers are experienced and 30% of them have been teaching mathematics for more than fifteen years. Most of the primary teachers (67.2%), rated diploma in education as their highest level of teaching qualification. A majority of 82.6% of the sample is trained and 13.8% is untrained. Sixty-three percent rated IGCSE core as their highest mathematics qualification. At the beginning of the study all fifty-eight teachers took part in the pre-test, making up both the (n=41) control and (n=17) intervention group. Ideally, it would have been more beneficial to the study if more participants had been willing to participate in the intervention group. This would have allowed for an even split between the control and intervention groups; and further enhanced the results of this study. Table 6.2 shows the composition of the control and intervention group. Forty-eight teachers, including the control group, completed a ten-week intervention study and took part in the post-test (a completion rate of 81.36%).

6.3 The Intervention Effects of RP on MKT Sub-domains (RQ2)

This section presents the analyses and results for Research Question 2.

6.3.1 The MKT Test Results

Using a quasi-experimental design, a mathematics test was designed by the researcher and administered to the participants, with the purpose of determining the potential effects of RP on MKT sub-domains and mathematics teaching efficacy. Fifty-eight (n=58) primary mathematics teachers were the subjects of this intervention study. Fifty-eight (n=58) teachers took part in the pre-test and forty-eight (n=48) took part in the post-test. Over the ten-week intervention period, pre and post-tests were administered to the teachers. The tests contained multiple-choice and open-ended items (see Appendix 17 and 18). The teachers' MKT from both the control and intervention groups was assessed before the intervention (pre-test) and again ten weeks later (post-test) using the same test paper. The pre and post-tests had twenty-five questions, and each question was allocated two marks to make a total of fifty marks for each paper. It was hypothesised that there would be a significant change in post-test scores of the teachers after the intervention. Table 6.2 shows the composition of the pre- and posttest groups. It is apparent from the table that the sample size of the intervention group is much smaller than the sample size of the control group and, interestingly, there was a full retention rate for the intervention group.

Table 6.2: Composition of pre- and post-test groups

Group	Before	After
Intervention	17	17
Control	41	31
Total	58	48

It is worth mentioning that such a difference could have a detrimental effect on the quantitative findings. However, the fact that the research findings are discussed within an interpretivist paradigm (see Section 5.3), it does not intend to make statistical inferences about the population (Mason, 2018).

6.3.2 The Kolmogorov-Smirnov Test and Levene's Results of the MKT Sub-domains Test

The data first went through the screening process, checking for missing values and outliers. Before any statistical analysis could be performed it was important to understand the distribution of the data in order to justify the type of test used (e.g. parametric or non-parametric). The Kolmogorov-Smirnov test (K-S test) verifies that the data sample comes from a normally distributed population. The K-S test was used to check the normality of the data. If the K-S test result shows that the probability value is less than 0.05 ($p < 0.05$), this means that the MKT scores do not follow the normal distribution. The pre-test was subjected to the normality test in SPSS. The test of normality gave the probability value of 0.2 (see Appendix 19 for SPSS output). This value is greater than the alpha value of 0.05. Therefore, the sample comes from a population that is normally distributed. Levene's test was used to check whether the variances in the control and intervention groups were approximately equal. In statistical terms, Levene's test was used to assess the hypothesis that there is no statistically significant difference between the variance of the first group and the variance of the second group. If the result of the Levene's test shows that $p > 0.05$, the test is non-significant, then equal variances are assumed. The Levene's test for the homogeneity of variances was also conducted on the two test samples and resulted with a non-significant value of $p = 0.477$ (see Appendix 20 for SPSS output). This result suggests that the variances were close enough to be considered equal. Therefore, the interpretation is that the baseline data analysis showed that there was no statistically significant difference between the control and intervention groups at the onset of the study.

6.3.3 Baseline Difference Test

An independent samples t-test was applied to determine whether there was a statistically significant difference between the control group and intervention group before the implementation of the intervention (see Appendix 21 for SPSS output). The t-test is designed to measure the statistically significant difference between two means. Table 6.3 shows the pre-test parameters of the two groups, and the participants' descriptive statistics of their responses to the pre-test.

Table 6.3: Descriptive statistics for pre-test conditions

Group	N	Mean	SD	Standard Error of Mean
Intervention	17	45.53	15.09	3.66
Control	41	47.56	14.33	2.24

NB: N= Number of participants, M=Mean, SD=Standard Deviation

What also stands out in Table 6.3 is that the control group has a higher baseline mean and smaller standard deviation than the intervention group. A small standard deviation means that the MKT scores for the control group are close to the mean. Higher standard deviation in the intervention group could be the effect of outliers. The t-test reveals no statistically significant difference in the mean for the intervention group ($M = 45.53$, $SD = 15.09$) and the control group ($M = 47.56$, $SD = 14.33$) with conditions: $t(56) = -0.484$, $p = 0.630$, at an alpha level of 0.05 ($p>0.05$). However, the t-test result suggests that the two-sample means are close enough to be considered equal. This implies that the two groups were comparable before the start of the intervention.

Research Question 2 sets out to verify any potential effects of RP intervention on MKT sub-domains. Such an effect is examined by comparing the teachers' responses from their pre-test with their post-test in both the intervention and control groups. The independent variables for this question are the intervention conditions such as the duration of intervention, characteristics of control and intervention groups; and the dependent variable was the teachers' change in MKT scores that can occur because of the intervention. Table 6.5 displays the composition, mean scores, and standard deviation of both the pre- and post- intervention MKT test.

Table 6.5: MKT pre and post-tests descriptive statistics

Test	Intervention Group		Control Group		Total
	N	M (SD)	N	M(SD)	N
MKT Pre-test	17	45.53(15.09)	41	47.56 (14.33)	58
MKT Post-test	17	49.65 (14)	31	47.10 (15.10)	48

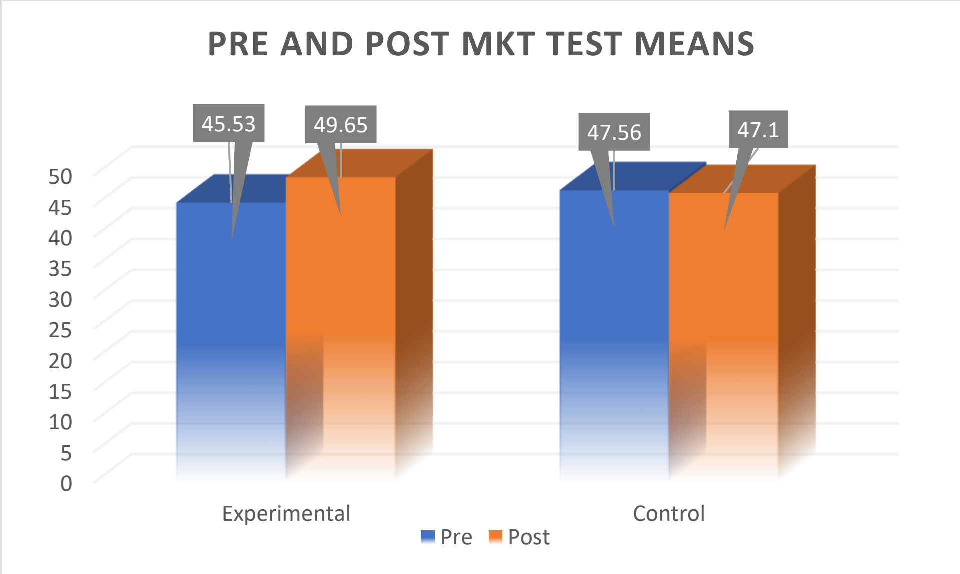
NB: N= Number of participants, M=Mean, SD=Standard Deviation

It is observed from Table 6.5 that the post-test score mean of the intervention group is higher than that of the control group. The results in Table 6.5 have been produced from statistical analysis in SPSS (see Appendices 5 and 22 for the SPSS group statistics outputs). The highest score achieved in the pre-test was 74% and the highest score achieved in the post-test was 80%. The mean difference for the control group did not change much. In fact, there was a very slight decrease in their post-test mean. The pre- and post-results of the control group confirm the reliability of the test instrument. Chakrabartty (2013) explains that the reliability of the testing instrument suggests that the same test score should manifest if the test is re-administered under the same conditions. The averages are almost identical, suggesting that the pre- and post-test scores of the control group are almost the same.

6.3.4 Analysis of MKT Test Results

Each MKT test item was marked either correct or incorrect, and then the results were checked by a second marker. The results of the test are illustrated in Table 6.5 and visually depicted in Figure 6.1. The striking results from Table 6.5 and Figure 6.1 shows an increase in the post-test mean score of the experimental group and a small decrease in the post-test mean of the control group. It shows the participants in the intervention group scoring higher in their post-test (M = 49.65, SD = 14), compared to participants in the control group (M= 47.10, SD =15.10). Figure 6.1 makes a visual presentation of both groups of their pre- and post-MKT test mean scores.

Figure 6.1: Pre- and Post-Intervention Test Means



6.3.5 Effects of RP on MKT Sub-domains: Hypothesis H02

An independent samples t-test was conducted on the data. There was no statistically significant difference in the MKT sub-domain scores of the intervention group (M = 49.65, SD = 14) and the control group (M= 47.10, SD =15.10), conditions: alpha level =0.05, t (46) = 0.574, p=0.569 (see Appendix 22 for SPSS output). Therefore, the null hypothesis H_02 was not rejected. The result suggests that teachers who participated in the RP session did not have statistically significantly higher MKT sub-domain scores than other teachers, even if there was an increase in their post-intervention mean score. The above results were further investigated using Difference in Differences (DiD) methodology in the next section.

6.3.6 Unbiased Estimate of the Causal Effect of the Intervention on MKT Sub-domains

In order to validate the independent samples t-test results, address the threat to internal validity, and avoid issues of causal claim (Section 5.9.2*),* the DiD methodology was used to fully answer Research Question 2. DiD is a well-known quasi-experimental design (Wing et al., 2018) and statistical technique with popular use in econometrics, as well as in current practices when making unbiased causal claims. The DiD methodology which was used to calculate the unbiased estimate is based on the model in Table 6.6 below.

Table 6.6: DiD calculation model

Group	Before (Baseline)	After (Follow-up)	Difference
Intervention (Experimental)	A	B	B – A
Control	C	D	D – C
DiD = (B – A) - (D – C)			

As discussed in Section 5.9.7, the DiD estimator makes a parallel trends assumption. The DiD methodology compares the change between the intervention group and the control group, whereas the independent sample t-test just compares the post-test scores between the two groups. Additionally, DiD considers confounding factors which otherwise are discarded by other approaches (e.g. t-test, ANOVA). As observed in Table 6.6, the DiD calculation is exemplified by the model: [DiD = (B – A) - (D – C)]. As an illustration, the effect of the intervention was estimated using the formula:

Treatment effect $\Omega = (S_{Post\_\ Intervention} - S_{Post\_Control}) - (S_{Pre\_\ Intervention} - S_{Pre\_Control})$, where S is the MKT sub-domain mean scores of the participants in the intervention and control group and S_{xxx_xxxx} represents the sample mean of S at the pre-intervention and post-intervention level. Table 6.7 illustrates the results of the analysis

Table 6.7: DiD estimation between the control and intervention group for MKT sub-domains

Group	Before	After	Difference
Intervention	45.53	49.65	4.12
Control	47.56	47.10	-0.46
			DiD= 4.58

NB: $S_{Post\_\ Intervention} - S_{Post\_Control}) - (S_{Pre\_\ Intervention} - S_{Pre\_Control}) = 4.12 - (-0.46) = \mathbf{4.58}$

Most importantly, Table 6.7 shows that, when adjusted in relation to the control group, the participants in the intervention group increased their MKT group score by an average of 4.58 points because of the RP intervention. Such change over time suggests that the MKT sub-domains of the teachers started showing signs of being positively influenced by RP. The DiD analysis produced an estimated effect of the intervention as a 4.58-point overall increase in the group MKT scores. However, the DiD findings and the raw data in Table 6.8, which shows the absolute MKT gains, must be cautiously interpreted.

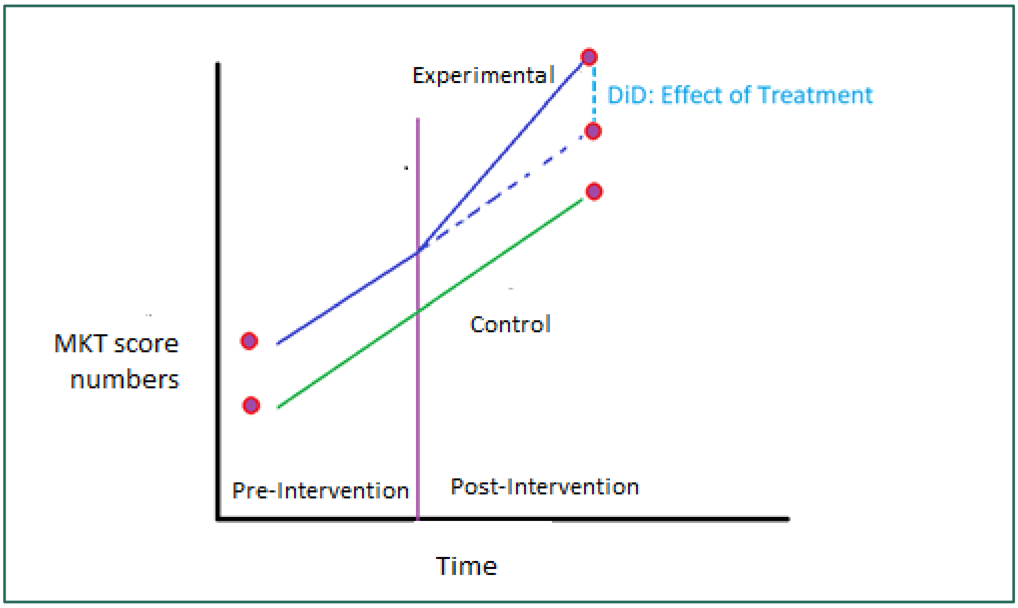
Table 6.8: MKT Gain scores of Intervention Group

ID	Pre-test Scores	Post-test Scores	Absolute MKT Gain Scores	Normalised Gain
7009	25	40	15	0.2
4944	44	58	14	0.25
2010	48	38	-10	-0.19
8495	60	52	-8	-0.20
3349	44	66	22	0.39
9445	28	24	-4	-0.06
2075	60	52	-8	-0.20
5395	66	64	-2	-0.06
2815	50	58	8	0.16
6492	52	66	14	0.29
6984	32	28	-4	-0.06
9788	62	62	0	0.00
5659	32	28	-4	-0.06
2902	38	40	2	0.03
8785	73	62	-11	-0.41
2630	24	54	30	0.39
0451	36	52	16	0.25
Mean	**45.53**	**49.65**	**4.12**	**0.04**
	SD= 15.09 CV=33%	SD=14.00 CV=28%		
Normalised Gain = (Post-test score - Pre-test scores) / (100-Pre-test score) **MKT Growth** = 8/17 = 47% of the teachers				

Table 6.8 shows quite a range in the scores. While there are eight participants who improved their scores, there are eight teachers who also lowered their MKT scores after the RP, and one teacher made no change. One possible explanation for this is the limited sample size of the intervention group which somehow provides quite a large variance in

the scores and makes it difficult to detect small intervention effects. This suggests that intervention studies should work with a bigger sample size in order to increase statistical reliability (Lavrijsen and Nicaise, 2016). The participants were later classified into four different groups using cluster analysis (see Section 6.6). One of the groups (Group 3) seems to contain those participants who made more loss in their MKT sub-domains test. Hence, one interesting question which needs to be answered is whether those eight teachers, whose scores decreased in the post-test, had enough mathematical knowledge to self-examine their belief that would lead to positive change in practice (Maksimovic and Osmanovic, 2018). While it was difficult to detect the small but important changes just by looking at the individual raw data, the DiD estimator suggests that the intervention group was experiencing growth over time in their MKT scores during the ten weeks of RP, as depicted in Figure 6.2. Thus, the argument is that a lengthier intervention period would have provided a better picture of the changes.

Figure 6.2: Visual DiD estimation of control and intervention groups



The DiD estimation indicates that there was an increase of 4.58 points over time in MKT sub-domain scores of the primary teachers due to the effect of the RP intervention. There is enough evidence from Table 6.7 and Figure 6.2 to suggest that the MKT of the teachers started developing after engaging in RP. This finding throws important light on the main research questions. However, the above analysis does not reveal much in terms of the significance of the 4.58 points increase. A DiD linear regression analysis would be required to capture the statistical significance of the increase. The statistical significance of the DiD estimate of 4.58 could be determined through programming using Linear Regression Analysis in R which is a statistical software. However, this was beyond the scope and purpose of this study because such analysis would require advanced programming skills in R; and, moreover, no generalisation of findings is required in this study. Still, the Linear Regression Analysis could be considered in any future extension of this research. Nevertheless, there is a qualitative analysis of interview data to further explore the participants' experiences of the intervention.

6.4 The Intervention Effects of RP on MKT Self-efficacy (RQ4)

This section presents the analyses and results for Research Question 4.

6.4.1 The Survey Questionnaires

To further assess the teachers perceived change in their own MKT (e.g. CCK, KCT, KCS, SCK and knowledge of curriculum) through RP, two self-efficacy MKT survey questionnaires (pre and post-questionnaires) were devised specifically by the researcher for such a purpose and administered to the participants (see Appendices 11 and 12 for questionnaires). It is important to note that the mathematics content which features in this study is word problem solving strategies (see Section 3.5). The survey questionnaires gathered both quantitative and qualitative data from the participants. The teachers' MKT and self-efficacy pre-intervention instruments consisted of eight demographics questions, fourteen MKT scale items (e.g. I can adapt my teaching to engage pupils' interest when teaching word problem solving strategies), twenty-four self-efficacy scale items (including self-efficacy for reflection), and three open-ended questions that dealt with MKT. The MKT and self-efficacy questionnaires consisted of a six-point Likert Scale ranging from 'Disagree Strongly' to 'Agree Strongly'. The post-intervention questionnaire was similar to the pre-questionnaire, except that it had six different open-ended questions. Those questions were for the intervention group participants to further develop their views of the RP. This chapter presents the responses of the teachers to their rated items. The open-ended questions were incorporated in the thematic analysis. The participants had to complete the questionnaires prior to the intervention and again after the intervention, with the purpose of testing their mathematics teaching self-efficacy levels. Fifty-nine pre-intervention questionnaires were administered to the participants, and fifty-eight were returned, thus a return rate of 98%. Similarly, fifty-nine post-intervention questionnaires were administered to the teachers. However, only forty-two were returned, thus a response rate of 71%. It was envisaged that there would be a significant change in the post-test scores and post-self-efficacy levels of the teachers after the intervention. Table 6.9 illustrates the composition of the pre- and post-intervention questionnaire grouping. It is apparent from this table that fewer participants from the control group completed the post questionnaires.

Table 6.9: Composition of pre- and post-intervention questionnaire groups

Group	Before	After
Intervention	17	17
Control	41	25
Total	58	42

For the survey each participant rated twenty-two MKT statements and twenty-three mathematics teaching self-efficacy statements. Numerical values were assigned to the Likert scale: Disagree Strongly (1), Disagree (2), Slightly Disagree (3), Slightly Agree (4), Agree (5), and Agree Strongly (6). This allowed the actual responses to be transformed to numerical scale values and analysed in quantitative terms. Their responses were added, and the total was calculated as self-efficacy level score. An acceptable Cronbach's alpha coefficient of 0.830 was reported by SPSS for the scale, thus exceeding Cronbach's alpha reliability threshold of 0.7 (Taber, 2018). This shows a good internal consistency in the scales.

6.4.2 Effect of RP on MKT Self-efficacy: Hypothesis H04

As a follow up of section 6.3, self-efficacy questionnaires were used to further capture the change in MKT self-efficacy of the participants. They are the same MKT domains that the MKT tests are trying to capture, except they are in the form of MKT self-efficacy for the teaching of word problem solving strategies. Table 6.10 summarises and presents the MKT self-efficacy mean change for the intervention group and control group before and after the intervention. The MKT analysis of the survey data in Table 6.10 shows that there is an overall increase in the scores of the intervention group and control group. However, there is a greater increase in the scores of the intervention group, with a percentage increase of 7.2% compared to 1.7% for the control group.

Table 6.10: Pre and Post MKT Self-efficacy Mean for the Control and Intervention Groups

Survey	Intervention Group		Control Group	
	N	M (SD)	N	M(SD)
MKT Pre-questionnaire	17	4.59(0.41)	42	4.61(0.41)
MKT Post- questionnaire	17	4.92 (0.14)	31	4.69(0.16)
Percentage increase = 7.2 %			**Percentage increase = 1.7%**	

NB: *M=mean, SD=Standard Deviation*

An independent samples t-test was conducted on the data. There was a statistically significant difference between the MKT self-efficacy mean scores of the intervention group (M = 4.92, SD = 0.14) and the control group (M = 4.69, SD = 0.16, conditions: alpha level = 0.05, t (8) = -2.495, p = 0.037), after the intervention. Thus, this result shows that there is a statistically significant difference in the MKT self-efficacy beliefs between the intervention and control groups (see Appendix 23 for SPSS output). The results suggest that teachers who participated in the RP session have significantly higher MKT self-efficacy beliefs than the teachers in the control group. A paired-samples t-test was also performed on the data to compare the difference between the MKT self-efficacy mean before and after the intervention for the intervention group (see Appendix 24 for SPSS output). There was a statistically significant difference in the mean before (M = 4.59, SD = 0.13) and after (M = 4.92, SD = 0.14), conditions: alpha level = 0.05, t (4) = -5.147, p = 0.007. The results show a significant overall increase in the MKT self-efficacy mean of all the MKT domains. These results suggest that all the five MKT self-efficacy domains were somehow influenced and enhanced by RP.

The five MKT self-efficacy means for teaching word problem solving strategies which were influenced by RP are depicted in Table 6.11.

Table 6.11: Pre- and post-intervention MKT self-efficacy domain mean scores for the intervention group

Pre- intervention MKT Sub-domains		Post-intervention MKT Sub-domains		% Mean Increase
Domain	**Mean**	**Domain**	**Mean**	
Common Content Knowledge (CCK)	4.65	CCK	5.06	**8.8%**
Knowledge of Content and Students (KCS)	4.79	KCS	4.96	**3.5%**
Knowledge of Content and Teaching (KCT)	4.53	KCT	4.71	**4%**
Knowledge of Curriculum	4.53	Knowledge of Curriculum	5.00	**10.4%**
Specialised Content Knowledge (SCK)	4.46	SCK	4.88	**9.4%**
Average	4.59		4.92	

Figure 6.3 visually shows the changes in the self-efficacy of the five knowledge types.

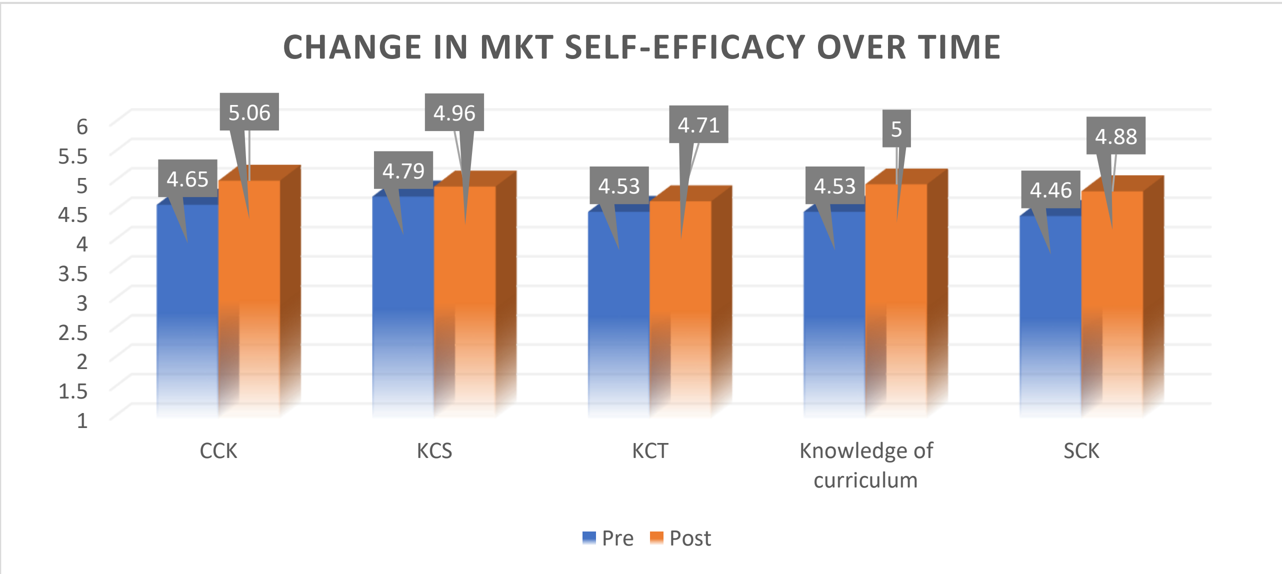


Figure 6.3: MKT self-efficacy means before and after the intervention

Specifically, Figure 6.3 shows interesting changes in the MKT self-efficacy beliefs specifically for CCK, SCK, and Knowledge of Curriculum for teaching word problem solving strategies.

6.4.3 Unbiased Estimate of the Causal Effect of the Intervention on MKT Self-efficacy Beliefs

In order to validate the independent samples t-test results, address the threat to internal validity, and avoid issues of causal claim, the DiD methodology was used to answer Research Question 4.

Table 6.12: DiD estimation between the control and intervention group for MKT self-efficacy beliefs

Group	Before	After	Difference
Intervention	4.59	4.92	0.33
Control	4.61	4.69	0.08
			DiD= 0.25

NB: $S_{Post\_Intervention} - S_{Post\_Control}) - (S_{Pre\_Intervention} - S_{Pre\_Control}) = 0.33\text{-}0.08 = 0.25$

Table 6.12 shows that the participants in the intervention group increased their MKT self-efficacy beliefs by an average of 0.25 of a point because of the RP. Such over time change suggests that MKT self-efficacy beliefs of the teachers started showing signs of being positively influenced by RP.

6.5 The Intervention Effects of RP on MTSE (RQ5)

This section presents the analyses and results for Research Question 5. As part of the intervention, the study also examined the effects of RP on mathematics teaching self-efficacy (MTSE) beliefs of the teachers for teaching word problem solving strategies (see Section 3.4.13).

6.5.1 The MTSE Survey Results

The sixteen self-efficacy scale items from the survey questionnaire were meant to measure the teachers' perception of their MTSE. The mean score, standard deviation, and percentage increase of the MTSE levels of the pre and post-intervention questionnaire are calculated and presented in Table 6.13.

6.5.2 Analysis of the MTSE Survey Results

Preliminary analysis of the survey questionnaire indicates a slight increase in the MTSE level of both groups of teachers. Using descriptive statistics, Table 6.13 illustrates the percentage increase in the MTSE level of both the control (1.6%) and intervention (5.7%) groups. It shows the participants in the intervention group scoring higher in their post-intervention MTSE level (M = 4.62, SD = 0.86), compared to participants in the control group (M= 4.49, SD = 0.81). However, more increase is observed in the intervention group compared to the control group.

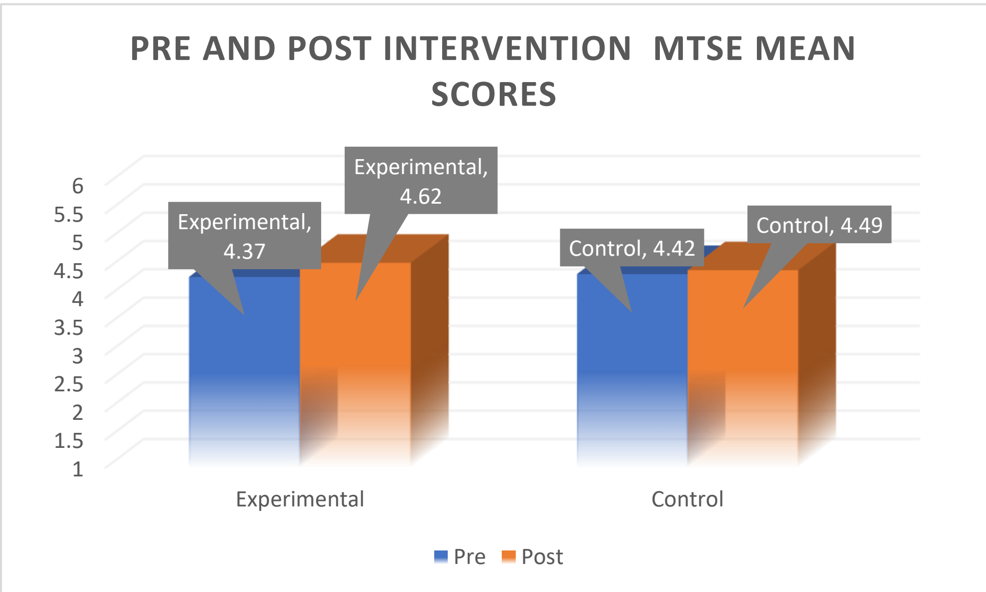
Table 6.13: Pre and Post intervention MTSE Means

Tool	Intervention Group		Control Group	
	N	M (SD)	N	M(SD)
Pre-questionnaire	17	4.37(0.82)	42	4.42(0.86)
Post-questionnaire	17	4.62 (0.86)	31	4.49(0.81)
	% increase = 5.7		% increase = 1.6	

NB: M=mean, SD=Standard Deviation

The increment in MTSE is further illustrated by the bar chart in Figure 6.4. The chart shows the improvement of the intervention group in their MTSE level after the intervention.

Figure 6.4: Pre and post intervention MTSE mean scores for experimental and control groups



6.5.3 Effect of RP on MTSE: Hypothesis H_05

An independent samples t-test was conducted on the data to find the statistically significant difference in the MTSE mean (see Appendix 25 for SPSS output). There was no statistically significant difference in the MTSE mean of the intervention group (M = 4.62, SD = 0.86) and the MTSE mean of the control group (M = 4.49, SD = 0.81), conditions: alpha level = 0.05, t (44) = 0268, p = 0.528. The results suggest that teachers who participated in the RP session did not have significantly higher MTSE scores than other teachers, even if there was an increase in their post-intervention scores. Hypothesis H_05 is validated using the DiD methodology in the next section.

6.5.4 Unbiased Estimate of the Causal Effect of the Intervention on MTSE

To further measure the effect of the intervention, a Difference in Differences unbiased estimator was calculate using:

Treatment effect $\pi = (S_{Post\_\ Intervention} - S_{Post\_Control}) - (S_{Pre\_\ Intervention} - S_{Pre\_Control})$

where S is the MTSE score of the participants in the Intervention and Control group and S_{xxx_xxxx} represents the sample mean of S at the pre-intervention and post-intervention level.

Table 6.14: DiD of MTSE level

Tool	Intervention Group		Control Group	
	N	M (SD)	N	M(SD)
Pre-questionnaire	17	4.37(0.82)	42	4.42(0.86)
Post questionnaire	17	4.62 (0.86)	31	4.49(0.81)
Difference		**0.25**		**0.07**
DiD =0.25-0.07		**0.18**		

NB: $(S_{Post\_\ Intervention} - S_{Post\_Control}) - (S_{Pre\_\ Intervention} - S_{Pre\_Control}) = 0.25-0.07=0.18$

The result in Table 6.14 shows the participants in the intervention group increased their MTSE belief scores by 0.18 points because of the RP intervention. Such over time change suggests that the MTSE belief scores of the participants started showing signs of being positively influenced by RP.

6.6 Cluster Analysis for the Grouping of Participants

For the qualitative analysis in this study, there was a need to classify the intervention group participants based on their similarities, or to identify similar groups of teachers within the data. Cluster analysis (CA) was therefore chosen for this purpose because this would provide a more practical understanding of the teachers' characteristics. Cluster analysis is a technique used to group objects based on traits or characteristics that make them similar. CA makes no *a priori* assumptions about the data. However, some criteria, such as the selection of variables, are important. The clustering technique used in this study is the K-means clustering analysis, involving an iterative algorithm which measures the *Euclidean* distance between the cases to determine their similarity. K-mean clustering was used because it is very easy to implement (Liu et al., 2017). The data set is divided into K clusters and each data point is allocated to a cluster with the nearest means or cluster centres. Different numbers of clusters were experimented with and finally the analysis of four clusters was chosen due to limited outlier. A few studies in educational research have applied CA techniques to group cases (e.g. Darcan and Badur, 2012; Alfiani and Wulandari, 2015; Alawi et al., 2017; Govindasamy and Velmurugan, 2018).

The CA approach in this study used data coming from the MKT tests and survey to group the teachers. The clustering analysis was conducted in SPSS version 26. During the analysis, the two variable items, the post-MKT sub-domain test gain and the post-MKT self-efficacy level, were used to classify the participants. Their values were standardised and converted into z-scores. A z-score represents the number of standard deviations away from the mean. The results of the K-means cluster analysis are presented in Table 6.15.

Table 6.15: Results of K-means cluster analysis

Participants (pseudonym)	MKT Gain	Clusters	Final Cluster Centres
Nadine	30	G1	0.000
Bryony	15	G2	0.171
Fumi	14	G2	0.853
Karin	22	G2	7.169
Libby	8	G2	6.834
Tilly	14	G2	0.833
Harriet	16	G2	1.190
Hana	-10	G3	0.755
Beatrix	-8	G3	1.250

Erika	-8	G3	1.252
Andria	-11	G3	1.758
Zak	-4	G4	2.002
Marla	-2	G4	0.318
Charlotte	-4	G4	2.226
Azuza	0	G4	2.003
Vignette	-4	G4	2.077
Zara	2	G4	4.065

MKT sub-domains: p (0.000) <0.05 and Self-efficacy: p (0.238)>0.05

After a systematic analysis in SPSS, the data in Table 6.8 show that it was possible to classify the teachers into four different clusters. The teachers were put in the clusters based on their MKT sub-domains and MKT self-efficacy (post-pre) differences. The significance of the MKT sub-domains with the associated probability value ($p=0.000<0.05$) suggests their MKT sub-domain scores were the determining criteria in allocating the teachers to the four different groups. The composition of the different groups is as follows: G1 (6%), G2(35%), G3(24%), and G4(35%) of the seventeen case study teachers. Each group of teachers (G1-G4) from the cluster analysis was then labelled around their MKT gain, which would facilitate the ‘telling of their stories’. The groups were labelled as follows: G1 = very high, G2 = high, G3 = average and G4 = low, in terms of differences in their MKT sub-domain gain. The fact that Nadine was uniquely placed in group one is worth attention. Such placement seems to reflect her profile characteristics (see Appendix 26).

6.7 Chapter Summary

This chapter has quantitatively explored the effects of RP on the MKT sub-domains, MKT self-efficacy beliefs, and MTSE beliefs for teaching word problem solving strategies. Firstly, the chapter has addressed Research Question 2 through the testing of the research hypothesis $H_0 2$ (see Sections 6.1.1 and 6.1.2). The results of the analyses using independent samples t-tests show that there is no statistically significant difference between MKT sub-domain mean scores of the intervention and control groups. The raw individual data for the intervention group shows that while eight participants increased their MKT sub-domain score, eight others experienced a decrease, which makes the findings rather inconclusive. However, the DiD estimator shows an over time increase in the MKT sub-domain scores of the intervention group, but no increase in the control group. In fact, the analysis shows a decrease in the post-intervention mean of the control group. The pre- and post-intervention means of the control group were close enough to be considered equal, even if theoretically a small post-test increment was expected. Secondly, the chapter addressed Research Question 4 through the testing of the research hypothesis $H_0 4$. An independent samples t-test was conducted on the MKT self-efficacy beliefs score for the intervention and control groups and the result was statistically significant. Such results suggest that the ten weeks of RP had a positive influence on the MKT self-efficacy beliefs of the teachers. Thirdly, the chapter addressed Research Question 5 through the testing of the research hypothesis $H_0 5$. The results showed an increase in the MTSE level of both the intervention and control groups. However, there was greater increase in the mathematics teaching self-efficacy level of the intervention group. The significance of the increment was examined through an independent samples t-test, and the results showed that there was no statistically significant difference between the MTSE levels of the two groups. The results of the study also showed that there was no statistically significant difference between the intervention group and control group in both their MKT sub-domains and MTSE scores. However, analyses using DiD estimator suggests that the intervention group was experiencing over time increments in both their MKT sub-domain and MTSE score. On the other hand, the results show a statistically significant difference between the MKT self-efficacy beliefs of the intervention and control groups after the RP. The chapter also used cluster analysis which classified the case-study teachers into four different groups, suggesting that there are four types of teachers. The groups were labelled as G1, G2, G3 and G4. These four types of teachers were later revealed differently in Section 8.4, through the typology of teachers' self-efficacy growth. Chapter 7 presents the findings from the qualitative data in order to answer Research Questions 1 and 3.

Chapter 7: Qualitative Data Analysis and Findings

7.1 Introduction

In Chapter 6 the quantitative analysis and results of the study were presented. This chapter presents the qualitative findings to answer these research questions:

RQ1. To what extent do the MKT sub-domains and MKT self-efficacy beliefs of primary teachers develop after engaging in RP?

RQ3. To what extent does the MTSE level of primary teachers change after engaging in RP?

The aim of this chapter is to report on the perceptions, experiences, and 'stories' of the teachers who took part in the study and experienced the effects of reflective practice (RP) on their mathematical knowledge for teaching (MKT) and their self-efficacy beliefs. Qualitative data used to answer the research questions was derived from reflective journals, interviews, field notes and open-ended questionnaire items. The reflective journals were underpinned by Gibbs' (1988) reflective cycle framework which guided the participants in writing about their experiences (see Sections 3.4.8 and 5.10.3 on Gibbs). This chapter partly focuses on the following seven themes which were identified from the qualitative data analysis: (1) Scrutinising practice to enhance performance, (2) Self-assessment within a transformative process, (3) Reshaping perception of capabilities, (4) Professional and experiential knowledge growth for change, (5) Awareness of practice and self-knowledge, (6) Changes in teaching and learning, (7) Creating pupil-centred learning environments.

This chapter also sets the scene for Chapter 8 which discusses the MKT and self-efficacy involved in the data pertaining to the teaching of arithmetic word problem solving strategies in order to answer the research questions. The purpose of this quasi-experimental multiple case study was to investigate the potential effects of RP on the MKT and self-efficacy beliefs of primary mathematics teachers within an interpretivist paradigm. That is, the qualitative data analysis and interpretation are given higher priority than the quantitative analysis. After this introduction, this chapter is organised into three main sections. Section 7.2 presents the cases and their profiles. Section 7.3 presents the findings, including the seven identified themes. Section 7.4 makes a summary of this chapter.

7.2 The Cases

Due to the interpretivist paradigm underpinning this study, it was not possible to eradicate the element of subjectivism in the selection of verbatim quotations as evidenced in the discussion for the illustration of the themes. The subjectiveness of the researcher is acknowledged through reflexivity (see section 5.9.8). The researcher maintained the objectivity of the research through careful reflection on the choices made in selecting the quotations. The quotations were not used to skew the reader's perspective. All the seventeen case-study participants contributed towards this study. In order to further contextualise the findings, background information is presented on the schools and the participants. All the schools' and teachers' names used in this chapter are fictitious. Each participating teacher in the intervention group is a case in this research. The reported cases in this qualitative chapter are seventeen primary school mathematics teachers in Seychelles, reflecting on their practices. Qualitative data were collected from the participants using interviews, reflective journals, and open-ended responses from questionnaires.

7.2.1 The Case-study Schools

The settings for the case study were ten urban and rural public primary schools in Seychelles. They were all co-educational schools working with pupils 6-11 years of age, with mixed-ability classes for mathematics and average class size of twenty-eight pupils. All the schools were headed by a headteacher during the time of the fieldwork. The average pupil population of the twenty-four schools was three hundred and thirty, with the largest being seven hundred and twenty-five and the smallest being one hundred and forty-four pupils. The schools serve a total of three thousand, two hundred and ninety-seven pupils. 90 % of the case study schools are spread over the main island of Mahé, with 10 % located on Praslin Island. The case-study schools represented 42% of the primary school population in Seychelles. The teaching staff was predominantly Seychellois, with two schools having a foreign female teacher each in their teaching force. The two foreign teachers were accepted on the study due to the reluctance of local teachers to take part. The schools offered basic primary education to all pupils (see Section 2.4).

7.2.2 The Case Study Profiles of the Participants

A sample of seventeen in-service primary school teachers ranging from year one (5-6-year-olds) to year 6 (11-12-year-olds) were cases in the study. The qualitative element of the research focuses on case studies of seventeen out of one hundred and twenty mathematics teachers from the ten case study schools, who gave their consent to be in the intervention group; and thus, consented to take part in the in-depth interviews, observations, and the writing of journals. The teachers were mostly Seychellois females (94 %), except for one male. Most of the teachers had over ten years of teaching experience (Table 7.1), except for Azuza who had four years of teaching experience. Azuza is also the only participant with an undergraduate degree in mathematics in primary education. Table 7.1 shows the participants' characteristics categorised by the MKT gain score and group. A positive MKT score means a gain, whereas a negative score means a loss in the post-test. The participants are seen in their respective groups which they were allocated to by cluster analysis (see Section 6.6).

Table 7.1: The case study participants' characteristics

Teachers (pseudonym)	Age at Time of the Study	School (pseudonym)	Teaching Level	Years of Teaching	MKT Gain	Group
Andria	42	Poivre	Year 5 Year 6	10	-11	G3
Hana	28	Aldabra	Year 3	8	-10	G3
Erika	38	Coetivy	Year 3	20	-8	G3
Beatrix	30	Cosmoledo	Year 3 Year 4	12	-8	G3
Charlotte	48	Bijoutier	Year 4 Year 5	27	-4	G4
Vignette	41	Aldabra	Year 5	21	-4	G4
Zak	28	Astove	Year 6	8	-4	G4
Marla	32	Assumption	Year 5 Year 6	12	-2	G4
Azuza	26	Moyenne	Years 2-5	4	0	G4
Zara	35	Coetivy	Year 1	15	2	G4
Libby	33	Cosmoledo	Year 3	13	8	G2
Fumi	46	Platte	Year 5 Year 6	24	14	G2
Tilly	29	Platte	Year 3	17	14	G2
Bryony	32	Bird	Year 3 Year 4	9	15	G2
Harriet	32	Bijoutier	Year 5 Year 6	12	16	G2

Karin	46	Bird	Year 5 Year 6	26	22	G2
Nadine	27	Poivre	Year 1 Year 2	10	30	G1

When participants score less on their post-test than their pre-test, it does not necessarily mean a sign of weakness. In the light of the interpretivist stance taken in this study, it could also mean that there have, possibly, been some changes in the knowledge set of these participants, but which were not well thought out due to limited mathematical knowledge. The profiles of these participants have been compiled using field notes, interviews, and reflective journals. The profiles of the participants are important for the interpretation of their stories because research has shown that the personal side of becoming a teacher determines much of their future classroom practice (Leeferink et al., 2019). Most of the participants viewed the writing of the journals as time consuming and more intensive in terms of data collection. This is because they were used to short and unreflective post-lesson evaluation tools. However, most of the participants remained optimistic about the possible effects of RP on their teaching. Most of them were inexperienced in reflective writing; and yet realised its benefits for their professional development. A profile for each participant is provided (see Appendix 26).

7.3 Findings

In this chapter the key themes are determined, presented and then discussed further in Chapter 8. The themes are described and supported with quotations from the participants.

7.3.1 The Case-Study Data Collection and Dataset

The data for these cases included field notes, in-depth semi-structured interviews (n=17), survey post-questionnaires (open-ended responses, n=102) and reflective journals (n= 52) written by (n=17) primary teachers over the intervention period of ten weeks during the months of February to April 2019 in Seychelles. This adds up to a total of one-hundred and seventy-one (e.g. 17+102+52) different case participant data sources. Through the in-depth interviews the teachers' views and perceptions about their RP experiences were sought. The conceptualisation of the reflective journal was a type of narrative enquiry in the form of individual classroom stories. The teachers had to reflect on their practices by exploring and articulating critical incidents which occurred in their teaching so as to make sense of them. Johnson and Golombek (2002:5) explain that narrative cannot be pulled apart from "the sociocultural and socio-historical contexts from which they emerged'. The 'open-ended questions' were questions from the semi-structured questionnaires which were flexible enough for the participants to provide descriptive information.

7.3.2 A Typical Mathematics Class at the Time of the Intervention

A typical case-study mathematics lesson at the time of the intervention could be labelled as a traditional teacher-centred mathematics class in transformation and transition to a pupil-centred class (see section 4.3.5). The general format of the lesson was that the teacher would present the lesson followed by pupil practice. That is, the pupils would generally work individually to find solutions to the problems with minimum meaningful engagement with the mathematics. The pupils would then share their solutions with the rest of the class. However, the teachers were attempting to move away from the traditional whole-class approach to the teaching of word problem solving strategies to a more pupil-centred approach, with varying degrees of pupil-centred instruction. For example, the pupils were not just blindly following the steps-rule for solving the word problems, but they were reasoning behind the rule as well as using an exploratory approach to solve word problems. The teachers were also developing their mathematical knowledge as the cases of Andria and Azuza below. In most of the cases observed, the teachers were acting as mere facilitators to learning. When asked about her learning and teaching experiences when using the PIES mnemonic strategy, Andria had this to say:

> *For example, I gave an example of a car. How many tyres in seven cars? So, the child should be allowed to draw the car, draw the number of tyres, and then manipulate using whatever operations they are comfortable with. So, this is just one of the benefits of allowing various kind of learners to express their understanding of the word problems. Now how does it support my teaching? Erm. It caters for my different learners.*
>
> [**Andria**, Interview]

Azuza compared the changes in her reflective journals:

> *Through this you actually see where you went wrong. Like when I did my first one, and when I did my second journal, I read the first one, and I compared it. It's different. Two different things. The second time I used it, I actually found out that you can use it with bigger numbers. Because my pupils gave it to me*.
>
> [**Azuza**, Interview]

The next section presents each theme with their respective categories and sub-categories. Narratives from the participants are used as evidence to support the claims they make pertaining to their development.

7.3.3 Key Themes from the Analysis

Cross-case thematic analysis identified seven dominant themes from the overall qualitative dataset that were closely related to some aspects of MKT sub-domain, MKT self-efficacy beliefs, and MTSE; and they were sequentially developed in the areas of knowledge, pupil engagement, and instructional strategies. This chapter does not report on all the analyses conducted in terms of codes and categories; only those codes, categories and themes which were relevant to the research questions were chosen for this report. As presented in Table 7.2, the themes were developed through interpretive thematic analysis of the interviews, reflective journals, and open-ended responses.

Table 7.2 Themes, Frequencies and Research Questions

	Themes	Frequencies	Research Questions
1	Scrutinising practice to enhance performance	27	1 and 3
2	Self-assessment within a transformative process	14	1 and 3
3	Reshaping perceptions of capabilities	41	1 and 3
4	Professional and experiential knowledge growth for change	90	1 and 3
5	Awareness of practice and self-knowledge	32	1 and 3
6	Changes in teaching and learning	42	1 and 3
7	Creating pupil-centred learning environments	25	1 and 3

The themes connect both the adopted conceptual and theoretical frameworks in order to tell a coherent story for each participant**.** Table 7.2 illustrates the seven identified themes, their respective frequencies and the research questions they are attempting to answer. In order to identify these seven themes, a personal interpretation of the data was made, guided by both the conceptual and theoretical framework of this study. It is worth noting that it is extremely difficult to keep a safe distance and try to maintain complete objectivity when conducting social research. In terms of reflexivity, my status as a teacher has helped to better understand and interpret the participants' 'stories' and experiences. The seven themes in the study emerged in relation to addressing Research Question 1 and Research Question 3. Thematic patterns were apparent across the different cases. Quotations are used to illustrate and reinforce each theme.

7.3.4 Theme 1: Scrutinising Practice to Enhance Performance

In the interview, Harriet typified the importance of reflective practice and how she reflected on her practice.

> *It has helped to reflect personally on my experiences and my feeling as well, the way I see things, the teaching, itself. When it comes to the different elements of it, the description, steps it gets me to describe whatever I have to do. What was my intention? What I wanted the pupils to attain then it brought me to express my feelings on what I was doing, Was it wrong? Was it right? Why do I think it was right or wrong? It got me to evaluate whatever I was doing.*
>
> [**Harriet**, Interview]

The achievement of positive change in MKT sub-domains and MKT self-efficacy requires the teachers to scrutinise their practices. The first theme is 'scrutinising practice to enhance performance*'* which is illustrated in Table 7.3 (see Appendix 27). The table shows the distribution of the sub- categories. The data for this theme was taken mostly from interviews and reflective journals. All the themes, categories and sub-categories are important in telling the stories of the participants. In relation to the literature, this theme is almost equivalent to the first dimension of Zwozdiak-Myers' (2012) nine-dimension model of RP. Zwozdiak-Myers labels her first dimension as 'study their own teaching for personal improvement'. This emergent theme refers to stories about the teachers working with the PIES strategy to enhance word problem solving strategies of their pupils. More specifically, the theme is about the teachers questioning the status quo and making moves to change their practices. The theme name as a phrase was not explicitly used as such by the teachers. The essence of this theme is that it triggers the professional development phase and identifies the need for teacher knowledge enhancement through a reflective vision of change. This theme partially addresses both Research Questions 1 and 3. In this theme, the teachers shared their experience of scrutinising their practices in order to enhance performance. The theme shows evidence of the participants being more reflective and acknowledging RP benefits as expressed by Fumi below:

> *For me it helped me to grow to be more reflective….*
>
> [**Fumi**, Interview]

The Sub-categories

The theme has Informative and transformative reflections as a category and it includes the following sub-categories: critical reflection, reflection on action, deeper and more meaningful reflection and reflective writing is not a waste of time (see Table 7.3). Quotes are used to demonstrate the prevalence of the sub-categories and theme.

♦ ***Critical reflection***

There were twenty-seven references made to critical reflection. Examples can be found in the cases of Azuza, Beatrix and Bryony below.

> *But as I started reflecting deeply about things. I realise that there are so many things I can change if I sit down and have the patience to analyse what I have taught, analyse the things I did see, what was my weakness and what were my strengths and where can I improve from it really deeply.*
>
> [**Azuza**, Interview]

> *I should have planned the lesson otherwise. When planning the lesson, I should have taken into consideration the prior knowledge of the pupils as mentioned in the book 'Mindful learning'…. Also, somehow my focus was on completing the programme rather than considering the pace of learning of pupils.*
>
> [**Beatrix**, Reflective Journal]

> *Maybe I will take more time to analyse things that are happening in my teaching about me as a teacher personally, about the pupils and the way that they learn and the way that I am teaching.*
>
> [**Bryony**, Reflective Journal]

The cases of Azuza, Beatrix and Bryony typify other cases in this study where the participants develop their MKT through learning and teaching as they reflect critically on their practices to prepare better lessons for their pupils. Beatrix demonstrated that she now understood the PCK and strategies for the teaching of word problem solving. She also demonstrated her understanding of pupils (KCT) when she referred to their prior knowledge. The above quotes exemplify how engaging in critical reflection could support the teachers' knowledge growth and transform learning (Mezirow, 1990). While Beatrix was critiquing her established mode of teaching and assumptions, Azuza was trying to make sense of her teaching, and how she could improve on it. Asuza refers to the many things she could change through deep reflection. This was evidence of the possibility of transformative learning. Through this theme, critical reflection is seen as a subset of RP where the practitioner reflects and brings changes to deeply held assumptions and focuses on more relevant classroom practice (Brookfield, 1995; Fook, 2007; Dervent, 2015).

- ***Reflection on action***

As explained by Schön (1983), reflection on action occurs mostly after the lesson has been delivered and is a defining feature of professional practice (Seitova, 2019). Table 7.3 (see Appendix 27) indicates that, at most, twelve teachers (twenty-five references) referred to reflection on action. Typical articulated statements from the teachers on reflection on action were as follows**:**

> *As a teacher I can say that today I did not talk to that pupil, this one did not understand. When I go home, I say how do I get this one to get this part? I feel bad when a pupil cannot do something even if it is a low ability pupil. I have to find a way to get him to work on one or two.*
>
> [**Bryony**, Interview]

> *Reflecting on my lesson using PIES approach has also helped me as a teacher to be more aware and to orderly deliver my lesson without doubt or misconception. Also, it helped me to reflect on my next step for the low achievers*.
>
> [**Zak**, Reflective Journal]

From the two above quotes it is seen that reflection on action is one of the approaches used by the teachers to improve on their practices and the involvement of pupils by reflecting on their taught lessons or teaching moments. Zak noted that reflection on action helped him to work with the low achievers.

- ***Deeper and more meaningful reflection***

To implement change, some teachers conducted deeper and more meaningful reflections through problem solving and inquiry. A frequency of fourteen references were made to this category. In the case of Erika and Karin below, deeper reflection allowed their teaching practices to be challenged.

> *Why, because you have to go back, you have to think further. You have to put yourself back in that class where you have been and think about the different steps of your lesson. How did it go? The problems you encountered. What were your setbacks? The pupils in your class, how did they take the whole thing? I think it is a whole lot of reflection time. To tell you the truth it has not been easy.*

[**Erika**, Interview]

Through her deeper reflection, Erika was trying to question, interpret and create new knowledge while searching for alternative ways and solutions.

> *Some time we complain of pupils not learning, but we do not usually look at us to see why pupils are not learning. I do reflect on my ways of teaching as well. Even if I have a difficult class. I said that there could be something wrong with my teaching as well. Why are those could and this one could not? Maybe I could give more time for those. How would I do that?*
>
> [**Karin**, Interview]

By questioning her teaching style, Karin shared her thoughts on why pupils might not be learning.

♦ ***Reflective writing is not really a waste of time***

This sub-category highlights constant and interesting initial observations made by the participants in this study. They claim that they do not have time for RP and did not have the desire to participate in it because it was a tiring and demanding process. However, when they started to experience the benefits and power of RP, the interpretation of their narratives seems to show that RP is not really a waste of their time. Overall, they understood that the advantages of RP outweigh its drawbacks. Below are sample quotations from the teachers' responses about the value of RP:

> *I never did it for them sorry. I never did it for them. They are here to guide me. My focus is the pupils. I come here for the pupils. But this reflection turns things back to you as well, that I have to keep on reflecting. I do not have any choice. It is now that I am getting the opportunity to really reflect.*
>
> [**Harriet***,* Interview]

> *Lastly, I will continue to use the approach and reflect on my lesson as I have seen it has helped to be more structured in my teaching and also in the learning of the pupils*.
>
> [**Zara**, Reflective Journal]

Harriet's and Zara's words provide enough evidence to suggest that RP had positive effects on their practices despite its challenges. Hence, it is evidenced that the teachers were pleased in having participated in this research and to have benefited much from it as well.

7.3.5 Theme 2: Self-assessment within a Transformative Process

The second emergent theme identified in the analysis was 'self-assessment within a transformative process'. This theme suggests that RP enabled the teachers to undergo self-examination and change their worldviews as they addressed what is called a 'disorienting dilemma' in their classrooms (Mezirow, 1991). This theme is important to the study because it reveals the teachers' thought process as they examined their practices and themselves. Hence, this theme has a direct link to Theme 7 (e.g. 'creating a pupil-centred learning environment'). For example, after having reflected on her practice Erika argued that there should be a change in the way pupils are taught arithmetic word problem solving. It can also be observed that Erika's position leans toward the constructivist belief:

> *I strongly believe that the pupils should be taught about the situations and not the key word to help them solve problems solving. Teachers should provide regular exposure to a wide variety of word problems and lots of opportunities to practice.*
>
> [**Erika**, Reflective Journal]

This theme partly addresses RQ1. In this theme, the teachers embarked on a constructive learning process and inwardly explored their belief systems, values and assumptions in order to transform their perspectives and worldview for the benefits of their pupils' growth (Avalos, 2011:10). Table 7.4 (see Appendix 28) shows the distribution of the category and sub-categories. The sub-categories 'Positive attitude towards teaching' and 'Changes in assumptions and beliefs' came equally rated with the highest frequency of fourteen.

The Sub-Categories

The theme comprises of the category 'Self-assessment as a lens for learning', and four sub-categories: Positive attitude towards teaching; Exploring beliefs, values and assumptions; Changes in assumptions and beliefs, Changes in perspective; and Self-evaluation (Table 7.4). The sub-categories revealed from the analysis are as follows:

- ***Positive attitude towards teaching***

After the first two themes (see Table 7.2), the topics which came up in the journals and interviews were about having a more positive attitude towards teaching and learning, despite the difficulties the teachers were having. Table 7.4 in Appendix 28 indicates that, at most, fourteen teachers referred to this sub-category. There seems to be a paradigm shift in their attitudes. It should be clear that if the teachers take more positive attitudes towards the teaching of mathematics, then, it becomes easier for them to improve their practice. The extract from Azuza's interview below was one of the common attitudes of the teachers towards their teaching:

> *When I sit down to prepare the lesson. The strategy I am using, I have to reflect on it. How is it going to benefit my pupils? Can all my pupils learn from this strategy I am going to use? Will they understand the concepts I am going to teach today? Do I have to bring more strategies, more resources to help the pupils?*
>
> [**Azuza**, Interview]

Through her positive attitude Azuza was addressing both her beliefs, emotions and behaviours towards her teaching (Kreinter and Kinicki, 2007). She was also addressing her MKT (e.g. KCT and KCS) and pupil-centred teaching. Previous studies have proven a significant relationship between teachers' attitudes and classroom practices (e.g. Xie and Shariff, 2014).

♦ ***Exploring Belief, Values and Assumptions***

This sub-category came out mainly from the teachers' reflective journals. Theme 1 and Theme 2 initialised the process of change in the teacher (see Figure 4.1). Such change continues with the teachers exploring their beliefs, values and assumptions. Vignette's interview captured this exploration for change:

> *I feel very excited to use this strategy as I think that it will help the pupils to better understand problems. So, when I learn this strategy from Sir Bryan, I was eager to try it out in my classes. I feel that the pupils also find this method very beneficial. After using this strategy, I feel happy that I have got the chance to learn a new method which will help my pupils in maths as they are always underperforming in maths*.
>
> [**Vignette**, Interview]

Vignette was willing to put her beliefs to the test and tried out new approaches. Her new beliefs were constructed as she interacted with the pupils. Hence, the beliefs of teachers somehow influence their practices (Moru et al., 2014; Hong and Sing Chai, 2017). If the teachers are to change their practices, it should start with changes in their assumptions, beliefs, principles; and looking at them from a critical perspective (Farrell, 2011).

♦ ***Changes in assumptions and beliefs***

Many teachers spoke about changes in their assumptions and beliefs pertaining to learning in professional communities, which would normally precede changes in their practices. For example, Hana changed her assumptions and beliefs and saw that primary mathematics teaching could also be a collegial activity, as she described:

> *For example, when we are talking about languages, before you do a topic in language you need to conduct research, be more reflective, find other examples. But in maths I was doing but not like this. Before for maths I was looking in the 'Cracking Maths book', doing research on YouTube, but I was not consulting my colleagues about other ways.*
>
> [**Hana**, Interview]

The influence of and consultations with colleagues have changed Hana's initial assumptions, beliefs and attitudes. Slade et al. (2019) explain that transformative reflection allows teachers to challenge teaching assumptions and beliefs; thus, leading to change in practice regarding pupils' various needs.

♦ ***Change in perspectives***

Despite the challenges of change in their school environments, the teachers were prepared to modify their perspectives by suggesting radical changes in order to transform their practices. Karin explicitly lamented over this in the following extract:

> *I like the idea because from my point of view if we are trying methods that are not effective for all groups of pupils, then we need to find methods that can work for all pupils even though they are different methods*.
>
> [**Karin**, Reflective Journal]

Karin suggested that teachers should confront classroom realities and use teaching approaches that focus on individual pupils, and this could also mean taking a pupil-centred approach to the teaching of mathematics despite its challenges. Karin's strong conviction could be the findings of her own informal action research.

With a bit of self-assessment and reflection, Beatrix commented that she should change her feelings and attitudes towards the pupils when she faces difficulties:

> *Anyway, it is a way to help us to like at times we tend to get frustrated like when pupils do not understand a concept, it helps us to see that it is not their fault, they are learning. I need to change my feelings and my attitudes towards them when teaching them.*
>
> [**Beatrix**, Interview]

Azuza expressed a change in her perspective. Now she cares more about the pupils rather than what her colleagues would say about her:

> *Ya. I did not have the confidence. Most of the time when I would teach a subject, I would go to the internet prior to just check or go check with other teachers, that now I do more. So, this is how like my confidence. Now I don't have to say like, they would be saying things about me because I do not know much about this subject. So, if you do not know you just need to go out there and ask. My confidence of asking when I do not know has changed greatly*.
>
> [**Azuza**, Interview]

♦ ***Self-Evaluation***

Ross and Bruce (2007) explain that teacher self-evaluation is a powerful tool for professional growth in teachers. When considering the changes in themselves, teachers in this study lamented over how they should have planned differently in order to improve the performance of their pupils. Hana stated how she would transform their lesson planning:

> *Next time plan, plan, plan. Sit and think. Have a lesson to gauge pupil's level. Maybe get a test at the start. Research on problem solving. Have a format that we stick to, so it sinks in the pupil's mind through repetition. Priority area is research. I need to get information on problem solving steps*.
>
> [**Hana**, Reflective Journal]

For Hana, her self-evaluation was a critical approach of looking to herself, assessing her teaching in terms of strengths and weaknesses; and then organising future teaching plans in order to improve her teaching. Her quote contains elements of self-efficacy beliefs, that is the perception of her ability to perform future tasks. Therefore, self-evaluation could contribute to self-efficacy.

7.3.6 Theme 3: Reshaping Perception of Capabilities

The third theme is 'reshaping perception of capabilities'*.* Xu (2012) explains that a teacher's beliefs are of the essence in understanding and improving the learning process. In this theme, the teachers shared their perspectives on shaping their mathematics teaching self-efficacy beliefs, and their confidence.

For example, Hana commented on how RP has increased her confidence in the teaching of mathematics:

It has increased my confidence in maths and also has boost up myself because I know when I am standing in front of the class, I am not just saying anything because I know this can be true or this can be wrong, because I am saying something that this is true. I know that 2 plus 2 is 4, so 4 plus 2 is 6. I know what I am saying, I am not just saying anything out of the blue.

[**Hana**, Interview]

However, one participant claimed that her self-confidence was always there:

No, my self-confidence is always there.

[**Fumi**, Open-ended Item]

This theme is important to the study because teachers with high efficacy have been linked to high pupil success (e.g. Skaalvik and Skaalvik, 2007**;** Fackler and Malmberg, 2016). The theme partly addresses Research Question 3. Table 7.5 (see Appendix 29) shows the distribution of the categories and sub-categories which support the theme. One should note that the sub-category 'self-confidence in teaching mathematics' is the one with the highest frequency.

The Sub-Categories

The theme comprises the category 'Efficacy beliefs and self-confidence' and three sub-categories: High sense of efficacy, Improved self-efficacy, and Self-confidence in teaching word problem solving strategies. The sub-categories are presented below.

♦ ***High sense of efficacy***

The interviews and reflective journals demonstrated the teachers' efficacy beliefs, self-confidence, and contains evidence of their thinking process. Evidence suggests that teachers had a low sense of efficacy prior to the intervention, but then there were positive changes in their mathematics efficacy. Quotations from Libby and Karin typified this aspect:

In the future as I use the strategy, I will come up with more innovative ways to present the PIES by using different diagrams, using the same components. I will also set up a more realistic time frame so as not to pressure the pupils to finish on time, but to give them the adequate time to work on their own pace and explore the strategy entirely.

[**Libby**, Reflective Journal]

Teacher Karin made this remark:

I knew exactly what I was going to do and, how to improve on my previous lesson with the other class.

[**Karin**, Reflective Journal]

The quotes show the personal sense of efficacy or convictions of the teachers in being able to positively shape the learning outcomes of their pupils. The case of Libby shows that higher personal goals were being set and she was sure of her own effectiveness as a teacher.

♦ ***Improved self-efficacy***

Close scrutiny of the data reveals the perceptions of some teachers of their enhanced self-efficacy level. After reflecting on how some of her former teachers taught her, and now the improvement she has made in her teaching, Vignette made this comment:

I feel that teachers from back can have enormous impact on the young teachers. This is it until you want to make a change, then the same history will repeat itself. Unless you make a change, you will destroy people's enthusiasm about mathematics. Then I want to change that. Full stop.

[**Vignette**, Reflective Journal]

Oher participants also commented on their new sense of self-efficacy. For example, Beatrix stated:

From this experience I have learnt that my teaching can have a direct impact on the learning of the learners. That I have the ability to help the learners to be competent in solving word problem in maths, considering the PIES mnemonic strategy.

[**Beatrix**, Reflective Journal]

Contrasting the two above cases, Vignette seemed to be expressing some frustration about her past teacher training which has affected her practice. But then she showed her improved efficacy by promising radical change in her own teaching. On the other hand, Beatrix associated her improved self-efficacy with her classroom performance.

♦ ***Self-confidence in teaching mathematics***

A significant relationship has been found between self-confidence and classroom performance of science teachers in Jakarta (e.g. Sriyono, 2018). Most participants were of the opinion that they were now more confident in tackling teaching tasks which had not been possible before the change in their mathematical knowledge. However, the quotations below show that some of the teachers lacked self-confidence in the teaching of mathematics but were using the opportunity provided in this research to gain back their confidence. Tilly and Zak made these remarks:

> *Yes, it has brought back my confidence in teaching mathematics, because when I had the group. I had the first group teaching the PIES mnemonic. I was more eager to do the same with the other groups.*
>
> [**Tilly**, Interview]

> *Yes, I am now more confident and self-aware when teaching word problem solving.*
>
> [**Zak**, Open-ended Responses]

On the other hand, Marla stated:

> *Confidence in teaching mathematics! Like I said, I was trained to teach specifically chemistry. So, teaching mathematics was a challenge for me. So, the RP so far like I have said, I have so far been able to give you only one journal. So, I will be trying to kind of put more images, more, how to say, more pictures in the lessons whenever it is possible for the pupils to learn. That's it. Changes in the confidence, not really as such. Not really.*
>
> [**Marla**, Interview]

Marla was worried and struggling to teach, because she had never been trained to teach primary mathematics. Her lack of confidence was linked to her limited MKT as well as being inexperienced in teaching mathematics. From this study's perspective, Marla's case is worrisome because teachers' confidence has been linked to teacher quality.

7.3.7 Theme 4: Professional and Experiential Knowledge Growth for Change

Slade et al. (2019:1) state, "RP facilitates the development of new knowledge, skills, and dispositions in teachers". One of the coding areas which quickly spiralled during the analysis was later given the theme name 'Professional and experiential knowledge growth for change'. This generative and emergent theme is important because it contains *a priori* sub-categories linked directly to the research questions and to Ball et al.'s (2008) MKT framework. The MKT framework suggests teachers need six different types of knowledge to effectively teach primary mathematics. This theme is underpinned by the category 'acquisition of new knowledge', five *a priori* sub-categories and one emergent category. This theme is important to the study because teachers' knowledge has been acknowledged as having positive links to pupils' learning outcomes (Hatisaru and Erbas, 2017). As illustrated in Table 7.6 (see Appendix 30), the five *a priori* sub-categories are:

(1) KCT, (2) KCS, (3) CCK, (4) SCK, (5) KC; and Improvement in teacher knowledge as an emergent sub-category. These first five sub-categories were *a priori* codes from five of the six Ball et al.'s (2008) MKT sub-domains. Similar to the pilot study results, the analysis identified five of the six theoretical MKT sub-domains that were relevant to the emerging category. In this theme, the data sources are analysed to determine the aspects of MKT expressed in their contents. Table 7.6 shows the strands and frequencies of the 'acquisition of new knowledge' category revealed in the in-service teachers' reflections, interviews and survey. Table 7.6 also shows the frequencies of strands of MKT revealed in the in-service teachers' reflections, interviews and open-ended responses. Most importantly, the theme exposes the knowledge types that have been mostly affected by RP. This current theme refers to instances where the participants referred to a change or growth in their knowledge of how better to implement the teaching of word problem solving strategies in arithmetic. Table 7.7 (see Appendix 37) shows the definitions of the *a priori* sub-categories as interpreted in the data. The findings show that the teachers referred to all five types of knowledge for teaching mathematics. KCT is the category with greatest number of data sources in this study. Table 7.6 shows that thirty-one journals and fifteen teachers made reference to some sort of growth in their KCT with a frequency of ninety. Similarly, eighteen journals and sixteen teachers made reference to some sort of growth in their KCS with a frequency of sixty-two. The other knowledge types referred to by the teachers, and their respective frequencies were SCK (eleven), Knowledge of curriculum (ten), CCK (eleven), Improvement in teacher knowledge (fourteen). It is important to note that Improvement in teacher knowledge is not an MKT sub-domain, but the teachers referred to it as part of their acquisition of new knowledge. The content of this intervention study was that the teachers would reflect on their practices as they taught arithmetic word problem solving strategies to their pupils using the PIES mnemonic strategy.

The Sub-categories

When analysing and interpreting the qualitative data, it was evident that the teachers were facing some serious challenges. However, data interpretation revealed that they were finding ways to improve their mathematical knowledge and instructional practices. The following cases show the types of knowledge growth present in the teachers' 'stories'.

- ***Knowledge of Content and Teaching (KCT)***

In this study, KCT, as a PCK sub-domain, is the combined knowledge of pupil, teaching and mathematics; and considered to be a major knowledge type for teaching (see Section 3.3.1). Teachers very often combine the three types of knowledge to plan their lessons. Evidence from Table 6.11 shows that there was a 4% mean increase in the KCT of MKT post-tests of the case-study teachers. Evidence of the existence of KCT is rooted in the teacher reflections and interviews. Teachers linked the changes in their KCT (e.g. new teaching strategies) to experiential learning and anticipated that such changes would affect the rest of their practice. For example, Beatrix made the comment below in her journal:

> *By teaching this lesson this way mentioned above, I have myself gained new strategies that I can eventually use in other lessons. It was a quite positive experience, and I am planning to use it again in another lesson*.
>
> [**Beatrix**, Reflective Journal]

Most of the teachers' narratives that involved changes in the planning of lessons and dealt with the formulation of ideas for teaching (e.g. illustrations, examples) are evidence of growth in their KCT. Beatrix was describing changes in her KCT. It was about new ways of formulating her problem-solving strategies so that she could be properly understood by her pupils. Azuza explained her newly found KCT in the following way:

> *I had all my resources for the lesson because I know what I was going to teach, but I did not follow the lesson plan as I got it too late. I did not use the appropriate method to teach word problems, but after being given feedback from the management that observe me that day, I will use the good ideas to teach my lesson and be more prepared*.
>
> [**Azuza**, Interview]

In the above case Azuza became more efficacious in her KCT after receiving feedback from the school management and reflection on action respectively.

- ***Knowledge of Content and Students (KCS)***

As discussed in Section 3.3.1, KCS is a combination of the knowledge of the pupil, of learning and of mathematics as well as expectations and predictions of pupils' possible answers or thinking. The two excerpts below are reflections of some of the teachers on their KCS:

> *I felt that if I had presented the problem step by step to the pupils, that would have helped them understand that the problem they are going to solve involved different steps and that they need to use two different operations to solve the problem*.
>
> [**Karin**, Reflective Journal]

> *To conclude, I feel that the PIES mnemonic strategy has helped my pupils to have a better understanding of the steps they need to go through to solve given word problems.*
>
> [**Vignette**, Reflective Journal]

Based on her new newly acquired KCS for problem solving Karin was able to identify weaknesses in her teaching. Similarly, Vignette better understood the positive influence of PIES on her pupils in understanding the solving of word problems. However, there were differences among the teachers in terms of how they acknowledge their KCS for word problem solving. For example, Karin was quite detailed in her explanation compared to Vignette. This could be that Karin had more KCS and more experience with word problem solving than Vignette (Barlow and Cates, 2006).

Karin commented on her successful use of her newly found knowledge of KCS to help her pupil with problem solving:

> *I was feeling confident and motivated, pupils could use their prior knowledge of adding and subtracting integers to solve problems. During the lesson I was thinking of various strategies to re-teach the lesson if pupils had misconception. After the lesson and consolidation activity I was pleased at least 75% of the pupils were able to use number lines to solve problems with integers.*
>
> [**Karin**, Reflective Journal]

- ***Knowledge of Curriculum***

Knowledge of curriculum (KC) is also a PCK strand and refers to familiarity with the curriculum contents, strands pertaining to the topics being taught, and teaching resources (Shulman, 1986; Leavy and Hourigan, 2016). Ten references were made to this type of knowledge. Tilly explained how she tried to be resourceful:

> *Planning the resources itself was quite challenging and there were not enough Diene's blocks. I had to photocopy the Dienes block and give them to the pupils. Plus, in the groups I had to get the pupils to settle down and assign them with their responsibilities*.
>
> [**Tilly**, Reflective Journal]

KC matters for instruction. Hill and Charalambous (2012) explain that curriculum resources set the stage to engage pupils in mathematical thinking and reasoning. KC enables the teacher to organise appropriate materials which could improve the quality of instruction. For instance, Tilly's support with Diene's block would have allowed her pupils to make rich meaning and connections when solving their word problems.

- ***Common Content Knowledge (CCK)***

CCK is a strand of the SMK domain. This is a type of knowledge that is not unique to teaching mathematics. Non-mathematics teachers can have this type of knowledge as well. Excerpts from Erika's and Hana's interviews show examples of how CCK was enhanced:

> *…okay, the things that I have learnt is that once you have your problem you have to highlight, you have to take out key element in the problem, the information that you need, the number that will help you. What are the keywords, what operation will be able to help you solve this problem mathematically? Also, it shows that every problem has a solution. Whether you have to subtract divide or multiply. It is a whole step approach*.
>
> [**Erika**, Interview]

> *I have seen that when I was a pupil in primary, this strategy was not used. Therefore, myself I have missed out on strategies of how to step- by-step formulate a problem and solve it also. Now I have better understood how to formulate a problem. How to better solve it*.
>
> [**Hana**, Interview]

Erika and Hana expressed that they were able to acquire the rules and techniques in using the PIES mnemonic strategy to solve word problems. We should note in the above cases of Erika and Hana, that being low in CCK could be problematic for teachers because they would not be able to make the content accessible to pupils (Jakobsen, 2014).

- ***Specialised Content Knowledge (SCK)***

SCK is part of the SMK domain (see Section 3.3.1). The following comments by Azuza and Andria exemplify aspects of SCK:

> *Small numbers like if we are saying Mary has 4 flowers. Her mother gives her another 5. We can actually interpret that in so many ways. In the problem itself we can draw the flowers. Mary, then you draw the flowers and then mother gives her another,*

then you draw the flowers, and then now they know they have to count the flowers altogether.

[**Azuza**, Interview]

After that I asked the pupils to discuss what they had to do first in the problem (e.g. 5x7) and then the next step (e.g. 35+20). I chose pupils that had drawings that represented their answers. I had them show their work and explained their drawings. It is at this point that I told pupils that they'll review how to solve multi-step word problems by using the acronym PIES: draw a picture, label important information for each question, writing the equation and solving.

[**Andria**, Interview]

Azuza's and Andria's narratives exemplify types of mathematical knowledge that are unique to teaching, and they address mathematical content as well as its pedagogy. Both teachers were unpacking mathematical concepts which are crucial for the pupils. Interestingly, both teachers seemed to be well aware how learning should take place and selected the appropriate progression of tasks to assist learning and detect errors.

However, there was one teacher in particular who acknowledged that she did not feel the significant effect that RP had on her mathematical knowledge.

For the time being it has not done a great impact on my teaching because I have just started, just had the new format of writing the journals. Maybe in the future if I keep on writing the journal, I will see the benefits and impact on my teaching. The time frame was too short. I have not seen the great impact yet. Maybe in term three or next year I will see. If I keep on doing it, I will see the impact. But I have been a bit more focused. I have been a bit more reflective while writing this reflective journal.

[**Fumi**, Interview]

- ***Improvement in Teacher Knowledge***

In this study it was also important to identify all the types of knowledge developed by the teachers as result of RP. This theme closes with evidence of teachers explicitly expressing a type of general improvement in their professional knowledge. This aspect is exemplified by Harriet and Hana:

> *I will not say that I was reflective before. I write post lesson evaluations on what pupils learned based on what I gave them. I do not know if you are getting me. But now, I am growing, I am learning*.
>
> [**Harriet**, Interview]

> *Before I was not using PIES where one has to draw. I was making a story. From that story pupils formulated their own problem. But I find this one very useful because from this one you are able to draw the picture, pupils can also formulate a story with it. The PIES strategy can cater for all the pupils*.
>
> [**Hana**, Interview]

In general, the participants' comments imply that it was then that they were experiencing a real sense of improvement in their knowledge. Harriet acknowledged that: "but now, I am growing, I am learning". Both of the above teachers and the others linked their sense of improvement to their participation in this research. Also, the teachers' sense of improvement was brought about through their various interactions with different types of pupils and their learning activities.

7.3.8 Theme 5: Awareness of Practice and Self-knowledge

Schön (1983) suggests that RP has the potential to increase the awareness of the practitioners as they learn from their experiences, and to transform their work (Pollard, 2014). This emergent theme refers to 'stories' and narratives of the teachers of being more aware of their learning and the teaching environment which led to a modification of their ideas and beliefs (Vasquez and Harvey, 2010). The 'stories' are about the participants making personal connections to their practices. Teacher awareness has rightly been linked to RP (e.g. Leavy and Hourigan, 2016). This theme triggers the transformative phase of the teachers' experience and depicts the teachers being more aware of weaknesses in their practices.

The sub-categories

When analysing and interpreting the data, the qualitative dataset indicated that most participants were convinced that their sense of awareness had improved. Zulfikar and Mujiburrahman (2018) explain that teachers' classroom awareness is developed when they reflect on their feelings, emotions, interests, and curiosity. This theme has 'Self-knowledge and Awareness' as a category and it includes the following sub-categories: *Aware of professional weakness in practice; Self-awareness, Awareness of good practice; Aware of need of further professional development*; *More conscious of teaching and learning of individual pupil'; Aware that learning needs to take place in individual pupil;*

and Aware of pupils' weaknesses; as illustrated in Table 7.8 (see Appendix 31). Awareness was an abstract concept being explicitly expressed by the teachers in a number of instances as exemplified by Zak below:

> *Reflecting on my lesson using PIES approach has also helped me as a teacher to be more aware and to orderly deliver my lesson without doubt or misconception. Also, it helped me to reflect on my next step for the low achievers.*
>
> [**Zak**, Reflective Journal]

Zak's new sense of awareness of practice and self-knowledge made him approach and experience teaching in new ways. Also, part of being aware allowed Zak to discriminate between different kinds effective teaching processes and created greater trust in his own ability to improve classroom learning. Charlotte narrated that she is now a better listener than before, pertaining to lessons delivery. She explained that:

> *It has helped me to be, what can I say, a good listener, especially when teaching my pupils in the class and also when delivering the lesson, I am more aware okay, that the way the lesson is delivered will have an effect on my pupils. Okay*.
>
> [**Charlotte**, Interview]

♦ ***Aware of Professional Weaknesses in Practice***

From all the three main data sources it was evident that the teachers were more aware of weaknesses in their practices during the intervention. Twenty-three different journals referred to this sub-category. The extract from Karin typifies some of those weaknesses.

> *It has made me more aware that when teaching there are different components that I have to take care of, yes, I am confident in what I am doing. But maybe sometimes we just teach out of our experience, but it helps us to realise that in teaching there are different steps and different components that we have to look at.*
>
> [**Karin**, Interview]

Karin increased her awareness as a result of her involvement in this study. This made her more appreciative, focused and led her to take a more comprehensive approach to teaching and learning, in contrast with her previous passivity and laid-back teaching attitudes.

♦ ***Self-awareness and Awareness of Good Practice***

Examples of self-awareness were often about how the teachers were able to control their feelings in the classroom as they were going through the transformative process. This is expressed in Bryony's and Charlotte's narratives**:**

> *What worked is the problem solving as a class. Students wanted to come to the board to solve the problem. It was a two-way discussion. I asked questions and the pupils answered most of the time. However, I was frustrated and showed it, e.g. when they could not answer what I thought were simple questions, but I picked myself up and was patient and calm*.
>
> [**Bryony**, Reflective Journal]

> *I sometimes get frustrated when I have planned my lesson carefully and the pupils are not mastering the concept. I have planned to teach. But after much practice and constant monitoring pupils slowly get the understanding of the concept.*
>
> [**Charlotte**, Reflective Journal]

Bryony's and Charlotte's cases are illustrative of the teachers' awareness of their negative emotions. Yan, Evans and Harvey (2011) argue that negative emotions from teachers could have a detrimental effect on pupils' development and achievement. However, Bryony explained that she was able to get over her emotions. Therefore, building on such awareness, teachers can shape their own emotions. The teachers also became more aware of effective teaching. For example, Andria expressed that she was still not pleased with some areas of her teaching.

> *This lesson was very engaging for pupils which helped them to understand the concept. Although I feel that the whole group lesson went very well, I still feel that there are areas where I think I still need to improve on.*
>
> [**Andria**, Reflective Journal]

Andria's case is an example of teachers in this study who were trying to implement positive changes to their teaching. Their focus was more on the pupils rather than the actual teaching, as well as examining more what was being done in the classrooms.

- ***Aware of the Need for Further Professional Development***

Teachers being aware of their own professional-development needs was an area of discussion that came to the forefront. In most cases the participants were referring to opportunities to develop further their teaching skills and knowledge. For instance:

I will recommend more specialised training in the development of mathematical concepts and to explore in deep various problems solving techniques and strategies.

[**Hana**, Reflective Journal]

The above excerpt from Hana represents the voices from eleven reflective journals in which teachers suggested that they require further professional development. Thus, this was also an indication of weaknesses, and they were seeking improvement in some recognised areas in order to overcome those weaknesses.

- ***More Conscious of Teaching and Learning of Individual Student***

Reflecting on their teaching allowed the teachers to be more conscious of their practices. Various participants gave their views on this sub-category. This was shared by both Beatrix and Nadine.

...*Yes, I am now more confident and self-aware when teaching word problem.*

[**Beatrix**, Open-ended Responses]

So, this was a benefit for me and my class. And in supporting my teaching it helped me to be more aware and structured concerning the word problem skills especially detailing out my lesson plan and letting the children know what I expect from them and also what they need to do and how they need to do it.

[**Nadine**, Interview]

Beatrix and Nadine expressed more awareness when preparing lessons and teaching word problem solving strategies. Also, Nadine was checking the understanding, as well as reconsidering the needs of all the pupils.

- ***Aware of Students' Weaknesses***

Lamentation over the weaknesses of the pupils was a familiar narrative of the teachers in this study. One of the concerns was that the pupils had language problems which hindered their ability to solve arithmetic word problems. Generally, the teachers were able to mention the specific learning difficulties of the pupils. One of the examples given is from Vignette:

> *The majority were able to work on their own whilst two pupils in particular need extra support to place the numbers down. With the use of Unifix they were able to calculate the total*.
>
> [**Vignette**, Reflective Journal]

This extract illustrates some of the problems the pupils were having with mathematics. However, whilst acknowledging the struggles of the pupils, the teachers were also considering various approaches that would help to make them understand.

7.3.9 Theme 6: Changes in Teaching and Learning

This transformative emergent theme contains evidence of change in the participants and in their practices.

The Sub-categories

The theme comprises of the category *Efforts to improve practice* and six sub-categories: *Changes in teaching practice; Teacher learns something new and improves practice; Teaching for Social Justice; Improved skill sets; Teacher has better engagement with teaching task;* and *learn to be a more effective assessor.* These sub-categories are depicted further in Table 7.9 (see Appendix 32). It can be observed from the table that 'Changes in teaching practice' was rated with the highest frequency of forty-two. This theme is important to the study because it subsumes some specific types of transformation that the teachers are experiencing. In this theme, the teachers looked at their practices from a critical perspective and were trying to address important areas that weaken the learning process of the pupils. A brief description of the sub-categories is as follows:

- ***Changes in Teaching Practice***

This sub-category refers to various instances where the participants referred to positive change in their teaching practice which were not there before, as well as more time required for changes to take place. The following quotes from Nadine, and Erika testify to some of those instances:

> *It has helped my experience. I noticed that there were things I was not putting my attention on before and following the procedures that we talked about. We saw. It was an eye-opening experience for me. There were things that I was already doing and things that I were missing out on; and there were things that I amended on, and it helped me to reflect on teaching and learning*.
>
> [**Nadine**, Reflective Journal]

It has brought changes, but again if we had started it earlier, I am sure the volume of change would have been bigger.

[**Erika**, Interview]

In the above excerpt Nadine referred to how the journal writing has changed her teaching. Changes in teaching practice is one of features of RP laid out in the conceptual framework (see Figure 4.1). Nadine was experiencing a better quality of teaching (Hill and Charalambous, 2012). On the other hand, Erika expressed that more time was required for the expected changes to impact her teaching.

- ***Teacher Learns Something New and Improves Practice***

At a time when the teachers are facing challenges in their teaching of mathematics, they were eager to experiment with new ideas which could help them. Most of them testified that the PIES strategy had brought new life into their teaching, thus an increase in teacher learning. Hana and Azuza expressed their views as follow:

I have seen that when I was a pupil in primary, this strategy was not used. Therefore, myself I have missed out on strategies of how to step by step formulate a problem and solve it also. Now I have better understood how to formulate a problem. How to better solve it. How to do it step by step.

[**Hana**, Interview]

But, then the second time I used it in class, I realised that there are also ways of using it when it comes to bigger numbers. So, we tried to talk about it in the class. They liked it.

[**Azuza**, Interview]

Hana aired how she has learnt something new when using the PIES strategy in her teaching and how the scaffolding of tasks has helped her pupils. Both Azuza and Hanna went through experiential learning; Azuza realised that PIES could be used with bigger numbers. They were not learning from theory only, but also from their practice. Hana confessed that she never understood how to properly solve word problems but getting involved in this research gave her the guided opportunity to learn through experimentation.

- ***Teaching for Social Justice***

Wager and Stinson (2012:6) refer to teaching mathematics with social justice as "pedagogical practices that encourage a co-created classroom and provide a classroom culture that encourages opportunities for equal participation and status". Through this sub-category, the teachers appeared to insist that there must be another way to teach mathematics with fairness and equity, engaged in meaningful mathematical inquiries (Skovsmose, 2011), so that every child gets the opportunity to learn. Nadine and Zak expressed their teaching for social justice with the following words:

> *Using the pupil-centred approach had given the opportunity to tackle and help them to overcome their weakness and I feel that the pupils are more independent, and they are responsible for their own learning. By helping them to acquire the skills, to solve addition problems they will be able to apply it in their daily lives. I will say that out of the 32 pupils 21 of them, I will say will be able to try and tackle problem solving on their own, and the 11 will still need some help to tackle and solve problems*.
>
> [**Nadine**, Reflective Journal]

> *I will try my outmost to follow my pupils to the maximum. Test their prior, knowledge, know their individual needs and capabilities. I also feel that I need to help from another person for certain lessons so that I can help my low ability ones and the same time challenge other pupils more. I mean help them to move to the next level*.
>
> [**Zak**, Reflective Journal]

The two quotes from Nadine and Zak show that their teaching actions could have equity, fairness and positive social consequences for their pupils. For example, Nadine expected her pupils to be able to solve problems in their daily life; and Zak wished that all his pupils performed at a particular level.

- ***Improved Skill Sets***

The teachers implicitly and explicitly talked about their newly acquired skills set when asked about what new skills they had acquired. For instance, Harriet stated that it was never fun solving arithmetic word problems, but now the pleasure has come back which, according to her, is bringing fun into the learning of mathematics.

> *Because you know where you want to start, and you know where you want to end. Your ending, you want your pupils to follow these steps out. Work out the answer properly, so in a sense it makes word problem fun, fun to work with, it never used to be fun any way in my context. Anyway, that's another*

page, another story, but it is very effective compared to the experience of what I had. So, it is effective.

[**Harriet**, Interview]

♦ ***Teacher Has Better Engagement with Teaching Tasks***

The teachers implicitly spoke about being more engaged with the development of the teaching tasks and the tasks themselves. The designing of tasks was more carefully analysed and presented to the pupils. Increased engagement means being more psychologically focused on their actual teaching tasks (Kahn, 1990) as they went through the process of active and experiential learning. In her own words Hana expressed these sentiments*:*

When I sit down to prepare the lesson. The strategy I am using. I have to reflect on it. How is it going to benefit my pupils? Can all my pupils learn from this strategy I am going to use? Will they understand the concepts I am going to teach today? Do I have to bring more strategies more resources to help the pupils? Did I approach them in a good way? Was my English clear? Were they able to understand? Was I communicating well with them? Do I reflect on all of these before I prepare my lesson?

[**Hana**, Interview]

These cross-case narratives also show similar evidence of pupil-centred teaching and awareness of good practice expressed by Erika and Beatrix in Section 7.3.10, Theme 7. Here we see the teachers expressing more engagement in the teaching and learning tasks.

♦ ***Learn to Be a More Effective Assessor***

There was consensus among the teachers that RP turned them into better assessors of classroom incidents and learning. Saeed et al. (2018) and Hopfenbeck (2018) explain that teachers use assessment data to make informed decisions about teaching, instructions, and pupils' learning. Andria decided to challenge the high achievers differently in order to further check their understanding. On the other hand, Karin was understanding her pupils a lot more.

Next time I will try more complicated problems. This is to challenge the high ability pupils. For me to see if they have understood it well. Individual problems will be assigned check their level of understanding. I started to change the negative

> *aspect about this PIES and try to make it work to see what the results holds. Little by little I can see progress Now time will tell.*
>
> [**Andria**, Interview]

> *Students tell you a lot of things. The way they are presenting their work. Maybe if they feel happy, they will keep their exercise books clean. They will remember the teachers' instructions. They do not have to tell you but the way they behave when they are on task you have to be on the guard*.
>
> [**Karin**, Interview]

It is interesting to see how Andria and Karin, in different ways, integrated new assessment skills into their teaching to make informed judgments of the impact of PIES strategy on pupils. The teachers were developing new ways to assess the understanding of their pupils and then adjusted their teaching accordingly.

7.3.10 Theme 7: Creating Pupil-centred Learning Environments

The final theme to be presented is underpinned by the constructivist epistemology and was identified as 'creating pupil-centred learning environments'. Ahn and Class (2011) argue that social constructivist practices provide teachers with an arena for self-reflection. Dewey (1933) links reflection to action, and the action in this study is the creation of learning environments that are conducive for both the teachers and pupils to develop their knowledge and skills. In different ways, all the teachers were trying to create a classroom climate which would allow the learning of word problem solving strategies to fully take place. This theme is about the attempts of the teachers to place the pupils at the centre of the mathematics learning process which is the principle of constructivism. This generative and emergent theme comprises the category *'*Students' *progress'* and sub-categories*: 'Students learning something new', 'Change in students' learning', 'Students more engaged with tasks', 'Co-construction of knowledge through collaborative enquiry', 'Student-centred teaching', and 'Caring for pupils',* as depicted in Table 7.10 (see Appendix 33).

The theme is about learning in a pupil-centred environment. This environment allows the co-construction of knowledge. The theme is important to the study because it focuses more on the pupils. A pupil-centred approach to learning can be interpreted as when the teacher designs the learning activities and creates an environment so that the pupils are at the centre of the learning process; thus reflecting "dominance of principles of social constructivism" (Brouwer et al., 2019:119). In this theme, the teachers explained how the pupils are actively engaged with their mathematics much more than before, and how some of them are producing promising results. An overview of the frequency of sub-categories is provided in Table 7.10.

The Sub-categories

Table 7.10 shows the data sources, categories, sub-categories and frequencies for Theme 7. The sub-category *Students learning something new* was rated the highest with a frequency of twenty-five. Various data sources made contributions to this theme and thus this table. Based on the reviewed literature it was anticipated that RP would have positive effects on the practices of the teachers. The teacher comments were about co-construction of knowledge and pupil-centred learning.

- ***Students Learning Something New***

The *students learning something new* sub-category refers to narratives of both the teacher and pupils being overwhelmed and excited about their newly found knowledge in teaching and arithmetic word problem solving strategies. A significant portion of the participants made reference to this theme. In one of her reflective journals Andria told how the pupils were enjoying the implementation of their new knowledge and skills:

> *The pupils were very much engaged in the activity and displayed their newly found confidence by asking if they could help others by explaining how to apply the PIES strategy*.
>
> [**Andria**, Reflective Journal]

Zak observed a marked improvement in the pupils' understanding of a series of follow-up lessons:

> *There was remarkable improvement in their understanding of the topics. The pupils were able to state each step when doing problem solving and also explained how to place their sum to calculate the answer.*
>
> [**Zak**, Reflective Journal]

- ***Change in Students' Learning***

The teachers narrated significant changes in the pupils learning, as well as the way they were interacting in the class. Extracts from Harriet 's interview exemplified some of the changes:

> *The good thing was that pupils could work collaboratively, share ideas. After so many interventions, two groups out of five managed to solve the problems. I felt good for the two groups, but the other three groups were still struggling. During plenary*

> *discussion, mostly all pupils could understand the activity and able to solve the problem on their own*.
>
> [**Harriet**, Interview]

♦ ***Students More Engaged with Tasks***

From the analysis of the interviews, there was enough evidence of the pupils being more cognitive and socially engaged with the learning tasks through better planning over the course of the intervention as opposed to those who were initially disengaged. For example, in their own words Andria, Nadine and Zak expressed these salient examples:

> *The pupils were very much engaged in the activity and displayed their new-found confidence by asking if they could help others explaining how to apply the PIES strategy*.
>
> [**Andria**, Interview]
>
> *For the children I realised that they were more engaged.*
>
> [**Nadine**, Interview]
>
> *I have seen some pupils even doing the drawing before they are trying to solve the word problem*.
>
> [**Zak**, Interview]

Every week the content of the teachers' journals was different. There were increased reports of pupils' excitement and engagement in the classroom. This was what Andria meant in her interview. Her pupils wanted to share their newly found knowledge with others, which is much better than just listening to the teacher.

♦ ***Co-construction of Knowledge Through Collaborative Enquiry***

Co-construction of knowledge as one of the tenets of the sociocultural theory is a sub-category which refers to both the teachers and pupils collectively examining teaching and learning ideas through activities (Van Schaik et al., 2019). The learning process is moulded by the co-construction of knowledge. The following excerpts from the teachers' interviews are salient examples of this interchangeable aspect of knowledge construction. For example, Zara articulated that part of her experiential learning in this study led her to base her decision making on the learning needs of the pupils; and Bryony talked about getting the pupils involved in her decision-making process.

> *This experience helped to show me the need of learners and encouraged me to make decisions that is convenient for the learning of learners. Although I feel I have not yet achieved my*

teaching or learning goals, but it will better surely be an ongoing process. I am very hopeful somehow.

[**Zara**, Reflective Journal]

My action plan is still to improve on the teaching of solving problems. I even asked pupils their views and they gave me quite a good feedback.

[**Bryony**, Reflective Journal]

♦ ***Student-centred Teaching***

As stated earlier, at the core of social constructivist learning theory is the student-centred teaching principle, with the advantage of improving their cognitive and practical abilities (Wang and Zhang, 2019). Student-centred teaching approaches gathered from the reflective journals and open-ended responses was mostly about engaging the pupil in a hands-on exploration of arithmetic word problems. The teachers were mostly acting as facilitators of learning, as observed in the following excerpts:

Using the pupil-centred approach had given me the opportunity to tackle and help them to overcome their weaknesses and I feel that the pupils are more independent, and they are responsible for their own learning.

[**Erika**, Reflective Journal]

My teaching has changed a little bit errmm, like it has become more pupil-centred instead of teacher giving out the information. They were involved in the processed. okay and, that's it.

[**Beatrix**, Interview]

...prepare more pupil-centred lesson and act as facilitator.

[**Zak**, Open-ended Responses]

Through the pupil-centred approach to teaching and learning, the pupils were able to be more actively involved in the problem-solving processes, which could develop their thinking skills. This is obvious in the cases of Erika, Beatrix and Zak.

♦ ***Caring for Pupils***

The analysis and interpretation of the data revealed caring behaviour of the teachers towards their pupils. Lumpkin (2007) explains that caring teachers continually reflect on, and refine, their teaching strategies to ensure that the needs of their pupils are met. When asked why they chose teaching as a profession, most of them said that it was because they love and care for children. Bryony's statement is one example of how teachers care about their pupils:

> *I like to work with children not only for being there to deliver the lesson or being with them for academic purpose. I like taking care of them like their pastoral care, how they feel, what makes them happy. How they feel at home. If their parents ask what are they doing. A lot to do with their life skills. I am not perfect, but I feel that I am giving my heart to it because I take quite good care of them*.
>
> [**Bryony**, Interview]

The care expressed here was in terms of supporting, getting to know their pupils more, helping them academically, as well as being patient and persistent. For example, the actions of Bryony demonstrated her beliefs in intellectual and social care for her pupils which are prior conditions to learning (Hattie, 2012).

7.4 Chapter Summary

This chapter presented and elucidated on the qualitative findings from a case study of seventeen primary school mathematics teachers reflecting on their practices. The findings of this study revealed seven themes, seven categories and thirty-seven sub-categories which emerged from the data. Qualitative data has been used to partly tell the 'stories' of Azuza, Bryony, Erika, Fumi, Hana, Beatrix, Karin, Charlotte, Nadine, Vignette, Zara, Harriet, Libby, Marla, Tilly, Andria and Zak. Narratives were used to vividly exemplify the different aspects of their MKT and self-efficacy beliefs development identified in their data. Through the narratives, it has been implicitly suggested that the seven themes contributed to shaping the growth in MKT and mathematics teaching self-efficacy of the teachers. Findings from this study demonstrate overwhelming evidence from the teachers' responses that their engagement in RP has been the source for change in their MKT and self-efficacy.

The themes inextricably work together, to show that the RP intervention positively enhances the MKT and changes the self-efficacy of the teachers. MKT enhancement was evidenced by a richer view of mathematics teaching and focusing more on the actual mathematical needs of the pupils. The teachers were using different reflection strategies to diagnose their practices in order to get a better understanding of themselves, their practices and pupils. The scrutinisation of their practices using various reflection approaches appears to have benefited them because they were able to see gaps in their practices that they felt could be changed. The shaping of their beliefs in their capabilities was of paramount importance after the initiation of RP. The beliefs of teachers influenced both their behaviour and practices. The data revealed positive change in their perspectives, confidence and beliefs. With a high sense of self-efficacy, the teachers started seeing the learning difficulties of their pupils as challenges that they needed to overcome. The teachers implemented self-assessment within their classes to revise, challenge and transform their beliefs, assumptions, and roles. They appeared to have become more aware of issues and identified weaknesses in their practices in order to improve the learning outcomes of their pupils. New approaches to teaching and learning were being perceived and, already, pupils were making significant and promising progress in their learning of arithmetic word problem solving strategies. The next chapter merges the qualitative results and quantitative findings to produce a more in-depth discussion of the effects of RP on the MKT and mathematics self-efficacy of the teachers.

Chapter 8: Discussion

8.1 Introduction

Chapter 7 presented the qualitative findings. The purpose of this chapter is to triangulate the results and findings from Chapters 6 and 7 in order to answer the five research questions. The purpose of this multiple case-study research was to determine the effects of Reflective Practice (RP) on the Mathematical Knowledge for Teaching (MKT) and self-efficacy beliefs of seventeen in-service primary teachers in Seychelles using both quantitative and qualitative means. Seven themes were identified related to the effects of the intervention through the case study narratives. In this chapter a summary of the key findings is presented and then discussed in line with the research questions and previous studies; they are then merged for a more detailed discussion. This chapter is structured as follows: Section 8.1 introduces the chapter and provides a statement on the methodology of the study. Section 8.2 interprets and discusses the findings. Section 8.3 presents the seven -theme framework for teachers' professional growth. Section 8.4 provides a typology of teachers' self-efficacy growth. Section 8.5 presents a framework for enhancing MKT. Section 8.6 makes a summary of the chapter.

8.1.2 Statement of the Methodology

The review of literature revealed little research on the effects of RP on the MKT development and self-efficacy of primary teachers, apart from these limited close studies by Ní Shúilleabháin (2015), Bargiband et al. (2016), Leavy and Hourigan (2016), Slade et al. (2019), and Kuennen and Beam (2020) (see Section 3.4.12). The study is underpinned by social constructivist principles and the methodology is rationalised by the pragmatic paradigm (see Section 5.2). The research problem is central, and appropriate approaches are used to answer the research questions, without loyalty to any specific approach (Savin-Baden and Major, 2013; Cohen et al., 2018). The case studies were put together using data from fieldnotes, semi-structured interviews and reflective journals, tests and a questionnaire survey. Teachers in this research engaged in individual RP with the view of improving their teaching of arithmetic word problem solving strategies and its self-efficacy.

8.2 Discussing and Interpreting the Findings

The following five key research questions guided this research:

RQ1. To what extent do the MKT sub-domains and MKT self-efficacy of primary teachers develop after engaging in RP?

RQ2. Is there a statistically significant difference between the MKT sub-domain scores of the intervention and control groups after engaging in RP?

RQ3. To what extent does the mathematics teaching efficacy level of primary teachers change after engaging in RP?

RQ4. Is there a statistically significant difference between the MKT self-efficacy beliefs levels of the intervention and control groups after engaging in RP?

RQ5. Is there a statistically significant difference between the MTSE level of the intervention group and the control group after engaging in RP?

8.2.1 Summary of Research Findings

The study documented how primary school teachers reflected on their practices, which led to change in their MKT and self-efficacy beliefs. The findings corresponding to Research Question 2 from the MKT tests analysis suggest that there is no statistically significant difference between the means of the intervention and the control group on the five MKT sub-domains, and therefore are not in favour of the intervention group (see Section 6.3.5). On the other hand, findings corresponding to Research Question 4 show positive and long-term effects of RP on the MKT self-efficacy beliefs of the teachers. A t-test revealed that there was a statistically significant difference between the means of the intervention and the control group on the aspect of MKT self-efficacy beliefs in the pre- and post-questionnaires; thus, in favour of the intervention group (see Section 6.4.2). Findings corresponding to Research Question 5 show that teachers who participated in the RP session did not have significantly higher MTSE scores than other teachers, even if there was an increase in their post-intervention scores (see Section 6.5.3). To further answer Research Questions 2, 4 and 5, consistent findings from non-inferential statistical analysis using Difference in Differences (DiD) methodology (see Sections 6.3.6, 6.4.3 and 6.5.4) revealed positive over time changes in the MKT and teaching efficacy of the participants. In order to answer the first and third research questions, the qualitative dataset was examined for the presence of MKT and self-efficacy beliefs; and they were identified through seven major themes (see Section 7.3.3). These themes were seen as sources for the development of the teachers' MKT and self-efficacy beliefs. The purpose of the forthcoming thematic discussion is not to make causal claims regarding RP, MKT and self-efficacy beliefs; but rather to discuss and substantiate those claims with evidence. The next section discusses the research findings pertaining to the five research questions.

8.2.2 Interpretation of Findings

This study is grounded in the conceptual framework of Desimone (2009) (see Figure 4.1). Desimone depicts how an effective Professional Development (PD) works to influence change in the teacher, change in instructional practice and, therefore, improvement in pupils' learning outcomes. Such framework can also be used to evaluate the effect of PD. Therefore, the discussion in this chapter is viewed through the conceptual framework lens; that the mathematical knowledge gained and the change in efficacy had influenced the practice of the teachers. The theoretical framework is grounded in Mezirow's (1991) Transformative Learning Theory (TLT) and the social constructivism theory (see Section

4.3). Therefore, the findings in the research are discussed in the light of conceptual and theoretical frameworks.

8.2.3 Demographic Associations and Findings of the Study

The characteristics of the participants (see Table 7.1) were chosen and included to show background information relevant to the study. Such type of information would allow the researcher to report the findings in a context that can be better understood by the audience, as well as shedding light on the type of participants (Cohen et al., 2018). Also, the characteristics of the teacher participants is relevant because teacher quality influences the learning outcomes of pupils (Hattie, 2009). The prominent characteristics were gender, the age of the participants, schools, teaching level, number of teaching years, MKT gain and cluster (see Table 7.1). Although the influence of demographic characteristics on the findings would require a more detailed investigation using hypotheses, it is worth finding possible characteristic associations of the participants with the finding of the study. Gender of the participants is relevant because it provides a social balance to the research and the over-riding gender of teachers in primary schools in Seychelles was reflected in the sample. However, because it was an experimental study, the gender of the participants did not influence or contribute much to the findings of the study. The second demographic variable is age of the teacher. The researcher speculated that as the age of the teachers advanced, they would become more experienced or effective (Zafer and Aslihan 2012; Nyagah and Gathumbi, 2017). Instead, it was found in their reflective journals that some of those teachers who were more advanced in age were requesting formal training to update their pedagogical knowledge, and there were no clear age-related differences in the findings, especially in their MKT gains. The third characteristic is the teaching location of the teachers. There was no direct link of this variable to the findings of the study, except that some schools did not agree to take part in this study. However, the physical proximity of the teachers in the school was an important factor in the way they interacted and collaborated towards this research. This leads the discussion to the next demographic variable which is the teaching level of the teachers. It was evidenced from their reflective journals and interviews that some teachers on the same grade level were in consultation in the implementation of this research. It was easier for them to discuss and think about their lessons. Therefore, same teaching level interactions benefitted the teachers in this research. Additionally, across the grade levels most of the experimental group participants commented on the positive impact of reflective practice on their teaching. However, the research revealed no clear link between the teaching level and the finding of the study. The other variable is the number of teaching years of the participants. This variable is important because there is the assumption of a linear relationship between teachers' years of teaching and the quality of teaching (Graham et al., 2020), thus that the experienced teachers would bring more quality to their teaching. In this research the teachers' length of experience has little or no link to the findings of this study; except that, irrespective of their teaching experience, the experimental group teachers showed more interest towards the study and were hoping that their involvement would further increase their MKT. In terms of MKT gain as a demographic variable, the researcher hypothesised that its increase would be direct evidence of positive change in the teachers' MKT. However, due to the small sample size of the experimental group it was difficult to read much from this variable, and therefore no clear association of this variable could be made to the research findings. Similarly, using cluster analysis the teachers were classified into four groups. The researcher hoped to develop a clear typology of teachers based on empirical evidence. In this analysis, profiles of MKT gain score of the participants were used in the cluster analysis to create groups of teachers based on the similarity and closeness of their scores. The cluster analysis showed that even if the teachers were classified into different groups, there were no specific patterns in the rather small sample. Rather, there were unity and similarity in their stories pertaining to the effect of RP on their MKT.

8.2.4 MKT Sub-domains Enhancement in the Quantitative Data (RQ2)

This section discusses Research Question 2 (see Section 8.2). Nolan et al. (2015) argue that it is important to ask how MKT can be developed and measured. It was envisaged that RP as organised in this study would impact positively on the MKT sub-domains of the teachers. However, the results of the inferential statistical analysis of the MKT tests show no statistically significant difference in the MKT sub-domain scores between the intervention and control groups after engaging in RP (see Appendix 22 for SPSS output). This result is consistent with the findings of Kutaka et al.'s (2018) five-year longitudinal intervention study of the effects of their PD programme (e.g. Primarily Maths) on primary teachers' MKT in the areas of number and operations and geometry. In that study, the teachers experienced insignificant growth in their MKT after two years. While consistent with the work of Kutaka and colleagues, findings from this research differ to the study of Nolan et al. (2015) who found statistically significant differences in their teachers' level of MKT from their pre- and post-test survey. Taking into account that context and setting may affect PD programmes differently, one important possible explanation for failing to reach any statistically significant difference in the teachers' MKT could be that the ten-week period for this current intervention was too short for significant changes in the teachers to take effect. This suggests that modest intervention time may not be sufficient to change teachers' MKT. Also, getting through all stages of the seven, non-linear sub-processes in the reflective process (see Figure 8.2) would be time consuming. The limited period of the intervention was mentioned by some participants (e.g. Erika) when asked about specific mathematical teaching skills which they had then obtained; and the effects of RP on their MKT respectively (see Section 7.3.9, Changes in Teaching Practice). Even in the case of Kutaka et al.'s study, it took at least two years for positive small growth effects to be observed. However, RP was not a major feature of their PD programme. On the other hand, various studies (e.g. Moyer-Packenham and Westenskow, 2012; Phelps et al., 2013) have discussed the difficulties in changing teachers' MKT. For example, Moyer-Packenham and Westenskow (2012) in their analysis of twenty-two projects on growth in teacher content knowledge found that 32% used LMT items assessments (e.g. standardised MKT assessment items), and only 24% found significant difference in the teachers' MKT.

However, non-inferential statistics (e.g. DiD methodology and summary statistics) suggest that the five types of MKT considered in this study (e.g. CCK, SCK, KCS, KCT and knowledge of curriculum) of primary mathematics teachers may be influenced by RP (Table 6.5 and Figure 6.1). Closer inspection of the MKT test mean scores after the intervention using the DiD methodology revealed an increase over time in the intervention group mean and not in the control group (see Table 6.5). Evidence of growth over time in MKT is consistent with the analysis of the qualitative data in section 7.3.6. For example, we can see there that Beatrix appears to be joyfully anticipating the use of her new knowledge and Libby is expressing what she has learnt. The DiD methodology confirms what the teachers are saying. It is showing that, with time, the change in MKT could become more tangible. Based on the information processing theory and the constructivist theory, significant changes in knowledge and practice takes time. That is, people take time to reconstruct knowledge and assimilate new information (von Glasersfeld, 1993; Vygotsky, 1978). Table 6.7 shows the intervention group improved their MKT scores by 4.58 points. There were also gains of sixty points and twenty-six losses from the pre-test to post-test (Table 6.8). The gain of sixty points means that the teachers answered thirty more questions (e.g. 2 points per question) correctly on their post-test compared to their pre-test. This finding is consistent with that of Bargiband et al. (2016), with positive MKT growth of 83% of their teachers, compared to 47% in this study (see Table 6.8). Reflective practice was a major feature in both studies. A similar pattern of results was obtained by Leavy and Hourigan (2016) who identified improvement in the KCT and KCS of twenty-five pre-service primary teachers after a ten-week lesson study intervention focusing on early numbers. This result is also in agreement with those obtained by Ching-shu Shen (2015) who found that there were gains in the MKT of forty pre-kindergarten teachers after having experienced reflection in their teaching training programme. However, Ching-shu Shen's study was not targeting specific types of MKT. Even if the MKT sub-domain test result failed to reach statistical significance, the DiD analysis suggests that directing the teachers to focus and reflect on subject-specific pedagogy (e.g. word problem solving strategies), could have a positive effect over time on their MKT. The relevance and importance of this finding is that several studies have shown that teachers' level of MKT has a positive correlation with pupils' achievement (e.g. Hill et al., 2005; Baumert et al., 2010; Hanushek et al., 2019). Although the effect of the intervention on MKT sub-domain scores failed to reach statistical significance, one might interpret the findings of this study as showing that RP can have positive over time effects on MKT, which has been investigated within the limits of this study. This finding of positive growth in MKT brought about by experiential learning through RP is a way to bridge the distance between theory and practice. The quantitative part of this study predicted change in the teachers' practices and was confirmed by the qualitative findings discussed in Section 8.2.5. Furthermore, such findings add to the body of literature on MKT. While it was a small piece of research with limitations, and its findings need to be cautiously interpreted, the results demonstrate that RP could be used as a vehicle to assist teachers in the development of their MKT. On the other hand, the insignificant results point to the challenges and complexity in bringing change to teachers' MKT through PD, where several variables have to work together to make the change effective. The lack of a statistically significant difference does not mean that RP is not impacting on MKT. Instead, it indicates, without focusing on time, which is an important component of effective PD (Desimone, 2009; Desimone and Garet, 2015), that there will not be important growth in the teachers' knowledge (see Section 4.2.1).

8.2.5 MKT Self-efficacy Beliefs Enhancement in the Quantitative Data (RQ4)

This continued discussion relates to Research Question 4. The study hypothesised that RP would impact positively on the teachers' MKT self-efficacy beliefs of arithmetic word problems. The results of the analysis found that there was a statistically significant difference between the teachers' MKT self-efficacy beliefs across the intervention and control groups after the RP treatment (see Section 6.4.2). This is a promising result, because high efficacy has been linked to effective teaching (e.g. Klassen and Tze, 2014). This result corroborates with the argument made for RQ2 (Section 8.2.3) where positive change in MKT would trigger changes in the teachers' MKT self-efficacy beliefs as indicated by Aksu and Kul (2019) as well as Richardson et al. (2018). The basis for the teachers' development of their MKT self-efficacy beliefs takes saliency from the sources of efficacy theorised by Bandura (1997), particularly the Mastery Experience. This is evidenced through the narratives of the eight participants who populated the 'Mastery Experience' category (see Section 8.4 and Table 8.2). Figure 6.3 shows an increase in all the five types of MKT self-efficacy beliefs considered in this study. For example, one of the teachers, Tilly, said that she has the ability to help the learners to be competent in solving word problems in mathematics, using the PIES mnemonic strategy. Such a finding provides support for the effectiveness of the intervention. The results suggest that teachers who participated in the RP session had significantly higher MKT self-efficacy beliefs gain scores than the teachers in the control group, even if there was only a small increase in their post-intervention teaching efficacy level score as well. However, non-inferential statistics showed a positive over time increase of 5.7 % in the experimental group compared to a 1.6% increase in the control group (Table 6.12) of the teachers in their mathematics teaching self-efficacy beliefs.

8.2.6 MKT Sub-domains and MKT Self-efficacy Beliefs Enhancement in the Qualitative Data (RQ1)

As discussed by Van den Kieboom (2013), the current discussion highlights the connection between reflection and teacher knowledge, which are often disjointed areas in education. The findings in Chapter 6 show that MKT for number concepts, operations, and problem solving (e.g. MKT test contents) and MKT self-efficacy in particular, developed to some extent during the intervention period. Then, in Chapter 7, the analysis of the data identified seven themes highlighting the importance of RP in MKT and self-efficacy development. The themes were acting as sources working together for the MKT sub-domains and MKT self-efficacy development. Teachers' high sense of self-efficacy has been linked to pupils' positive learning outcomes. Therefore, it is in the interest of PDs to raise the self-efficacy of teachers (Carney et al., 2016). In this current research, the participants' narratives suggest that their MKT sub-domains for number concepts, operations, and problem solving, and MKT self-efficacy, developed after being exposed to RP. Therefore, in order to answer RQ1, the discussion highlights the MKT sub-domains and MKT self-efficacy involved in the narratives across the themes. Each theme is now discussed in relation to the first research question.

This research was an opportunity for the teachers to revisit, review and reconsider their knowledge of arithmetic word problem solving strategies in terms of content, beliefs, assumptions, biases, and efficacy. Based on the conceptual framework of this study (e.g. Desimone's, 2009 framework), a seven-theme model of teachers' professional growth (Figure 8.2) is identified as an outcome of the research findings. The model predicts that the teachers have to go through the complete framework or model for pronounced change to occur in their practices. All the qualitative datasets (e.g. interviews, reflective journals, open-ended responses) were examined for MKT growth and self-efficacy change.

Evidence of development of MKT sub-domains and MKT self-efficacy beliefs in the participants was found across the seven themes. Figure 8.1 depicts the theoretical process of change of the participants' due to RP. The seven themes suggest that development of MKT sub-domains and MKT self-efficacy beliefs are underpinned and guided by a series of processes and events to bring changes to teachers' knowledge and their instructional strategies (Tschannen-Moran and Woolfolk Hoy, 2007; Desimone, 2009). However, similar to Mezirows' (1991) TLT framework which underpins this research, it is not clear if the participants have to experience all of the stages in order to experience change in their MKT sub-domains and self-efficacy.

Figure 8.1: The Effects of RP on Teachers

All themes are inextricably linked to one another and interpreted as sources of participants' knowledge. Based on the sociocultural perspective also considered for the development of MKT sub-domains and MKT self-efficacy beliefs in the research (Vygotsky, 1978; Takahashi, 2011), the mathematical knowledge of the participants is being actively constructed and self-efficacy beliefs re-defined and shaped as the teachers interact with the pupils and the learning tasks in their communities of practice through the identified themes. For example, Themes 6 and 7 are linked through evidence in this study as well as with other existing studies, such as the work of Baumert et al. (2010) (see Section 3.2.6), where the PCK of teachers affected the mathematical achievements of pupils. Similarly, Themes 3 and 6 are linked in this study because the MKT framework does not consider the beliefs of teachers (Ball et al., 2008; Ní Shúilleabháin and Clivaz, 2017). This chapter revisits the seven-theme framework for teachers' MKT and self-efficacy growth (see Figures 8.1 and 8.1). The framework is used to develop the 'story line' of the participants based on their accounts. The 'theoretical precedence' approach (Birks et al., 2009) is used to guide the development of participants' stories. This is about making precedential connections between themes. The story line is about the development of the teachers' MKT sub-domains and MKT self-efficacy beliefs using RP. The themes are used as headings to provide structure to their 'stories'. The features of the themes are now unpacked to examine the MKT sub-domains and MKT self-efficacy involved in the teachers' journals, interviews and open-ended responses as presented in Section 7.3.

Scrutinising Practice to Enhance Performance

Teacher change can happen through scrutinising and reflecting on one's own practice (Mathew et al., 2017). For most of the participants, teaching is 'a dream job'. But then, they see themselves failing in their classrooms. After having understood what it takes to improve their MKT sub-domains and change their MKT self-efficacy, the participants use different approaches to inspect their current practices (e.g. Azuza and Beatrix on Critical reflection**,** Section 7.3.4). The participants see the need to authentically and critically think and reflect (Fook, 2007) on their practices for knowledge development, as explained by Hanuscin (2013) in Section 3.4.8. In the words of Mezirow (1991), that is to unearth and change very profoundly held assumptions of their practices. The narratives of the teachers provide evidence of them experimenting with and promoting various types of reflection (e.g. Critical reflection, Reflection on action, Deeper and more meaningful reflection). Ferraro (2000:3) comments that critical reflection upon experience continues to be an effective technique for professional development. Critical reflection is necessary because it grounds the teachers in the beliefs being held by the mathematics community. Evidence of growth in their reflections was observed in their journal entries as the weeks progressed. One of the examples of growth was Azuza **(**see Section 7.3.2) who compared her first two journals and realised that they were different in terms of content. This finding is consistent with those of Dervent (2015) who found improvement in the reflective thinking of physical education teachers through RP. Such findings could also be interpreted as evidence of growth in their mathematical knowledge (Turner, 2009). All the participants in the study acknowledged the benefits of their reflective inquiries in one way or another, even if they claimed that it was time consuming. The participants' comments genuinely suggest richer reflection and that they were constructing and gaining something from the RP experience. The unravelled data showed that it was an opportunity for the participants to converse with themselves.

Juxtaposing this theme with that of Mezirow's (1991) ten-phase transformative process (e.g. the theoretical framework), the participants' narratives were considered as a 'disorienting dilemma' in their classrooms because meaningful solutions to the learning challenges of the pupils had not yet been achieved. Through this theme you 'see' the participants critically thinking aloud, questioning their practices, trying to understand critical issues in their teaching in order to improve themselves and their pupils (e.g. Harriet in Section 7.3.4). In previous studies, RP has been shown to influence these types of critical thinking (e.g. Foong, 2018). The participants even verbalised their weaknesses (e.g. '…I should have planned the lesson otherwise...,' [Beatrix]; 'Maybe I will take more time to analyse things that are happening in my teaching…', [Bryony]). Masingila et al. (2018) explain that pupils learn while engaging with the tasks, whereas teachers learn when engaging through the task of teaching. In this theme, reflection is seen as a source of new knowledge. Therefore, as the teachers 'scrutinise practice to enhance performance', MKT is developed as they critically reflect on their practices and the pupils' learning task, thus making critical reflection a direct source of MKT development as identified by Van Driel and Verloop (1998) in Section 3.2.6.

Through a social constructivist lens, a large proportion of the teachers were more critical in their reflections as they examined and reflected on their experience of teaching word problems, thus leading to changes in their practices (e.g. Azuza and Bryony in Section 7.3.4). This finding is consistent with that of Masingila et al. (2018) who found that mathematics teacher educators developed their MKT as they moved into critical reflective enquiry and tried to understand the goals of their lessons. Using different types of reflection, the teachers were able to look at their teaching from different perspectives in order to improve their practices. As they moved into more critical reflection, they were able to change their thinking and considered new ideas (Kapsalis et al., 2019) as in the case of Beatrix (*Critical reflection*, Section 7.3.4).

To sum up, the key findings in this theme show the participants going through the professional development experience and using different types of reflection to transform themselves (Desimone, 2009). Their ability to think reflectively increased remarkably. This finding was also reported quite recently by Kramer (2018), who also found positive effects of RP on the PD of teachers. This intervention study was an iterative process of lesson planning, implementation and reflection using Gibbs' (1988) reflective cycle framework. The significance and contribution of this reflective theme to the research question and overall study is that this theme interacts with other themes in the seven-theme framework to influence change in the MKT sub-domains and MKT self-efficacy of the teachers. This is depicted in the second stage of Desimone's (2009) framework (see Figure 4.1). Additionally, sub-categories of this theme are considered as sources of MKT and MKT self-efficacy development. The finding is consistent with that of Turner (2009) who found that growth of knowledge for mathematics teaching had been influenced by reflection. Therefore, the MKT of teachers' arithmetic word problem solving is also impacted by these types of reflection.

Self-assessment Within a Transformative Process

Ross and Bruce (2007:146) explain that self-assessment "is a mechanism for professional growth". 'Self-assessment within a transformative process' was also identified as a theme among the participants, and a component of the TLT framework. Narratives supporting this theme are found in Section 7.3.5. A more positive attitude towards teaching and changes in the teachers' belief systems and assumptions has been found to be a determining factor of their instructional performance (e.g. Azuza). Azuza took a more positive attitude to her teaching and re-considered her MKT and its self-efficacy. Borg (2011) explains that teachers who engage in RP critically examine their beliefs and practices in order to change them. This theme reveals the start of the transformative effects of the PD on the participants. Such transformative effects led them to have a more positive attitude towards their teaching. Theme 1 overlaps into this theme, as self-assessment is part of reflection. This theme is about the participants assessing, questioning, and scrutinising their belief systems, attitudes, biases, knowledge and questioning their assumptions. Mezirow (1991), in his ten-phase transformative process, frames this phase as 'self-examination of assumptions' and 'critical reflection on assumptions'. Here, we see the participants questioning their frames of reference (Mezirow, 1991). Guskey (2010) posits that teacher should develop positive attitudes towards the teaching of mathematics. Furthermore, Beswick (2012) found that teachers' attitudes towards mathematics influenced the way they would teach the subject. Most of the teachers acknowledged a type of change in their personal belief systems as they compared and contrasted their actual level of competence with the expected one (Kapsalis et al., 2019). This is observed in the case of Erika (Section 7.3.5) through her new conviction of how problem solving should be taught. It was noticeable from the outset of their reflective journal writing that some of the participants displayed professional boldness in their future attempts to re-address teaching and learning weaknesses in their classrooms. This finding supports evidence from previous observations (e.g. Swars et al., 2018). Swars and colleagues, in their study of elementary mathematics specialists, found that some changes in beliefs happened quickly, while for other specialist teachers the changes in beliefs took more time. Qualitative data analysis showed a greater number of the participants being explicit about their change in assumptions, pedagogical beliefs, values, biases, empathy and knowledge. These features are observed in the narratives of Vignette (Section 7.3.5). Their strong beliefs could be explained by the model proposed by

Guskey (2002) in which he stated that teachers change their beliefs about their classroom practices after they have observed positive change in the learning outcomes of their pupils, as a result of changes in that classroom practice. For example, Vignette was more than happy to use the PIES strategy after it brought benefits to her pupils (Section 7.3.5). In short, the participants boldly expressed changes in their beliefs, attitudes, efficacy, skills set and knowledge towards their teaching (e.g. Azuza), which were hypothesised by the conceptual framework (see Figure 4.1). In a study conducted by Mathew (2012), he concluded that RP should allow teachers to challenge their assumptions and improve their instructional skills. Self-assessment within a transformative process is also seen as a knowledge development source because when the teachers self-assess and compare their actual knowledge to what is expected of them, new knowledge is developed. This observation corroborates with those of Bray (2011) who found a relationship between teachers' knowledge and their beliefs regarding mathematics instruction (see Section 3.4.13). No-one can refute this theme in answering the research questions. As indicated earlier in the chapter, studies have shown that teachers' beliefs determine their type of classroom practices (e.g. Sinatra and Kardash, 2004; Campbell et al., 2014). So, there is an obvious connection between teachers' knowledge and teachers' belief systems. Beswick (2012) argues that beliefs should be considered as part of teachers' knowledge (see Section 3.3.2). When one analyses the process of planning a mathematics lesson and its implementation, there is a clear connection between beliefs and mathematical knowledge. There was some evidence of change in the teachers' beliefs. For example, this is observed in the case of Karin in Section 7.3.5, where she shows a lack of satisfaction in her current practices and argues that teachers should implement a teaching method that works for all the pupils. Karin sees belief and practical knowledge to be connected. Therefore, a change in the belief system of the teachers through RP would also mean a change in their MKT and self-efficacy; hence, illustrating a positive effect of teachers' perspectives on MKT. Many studies have found a relationship between belief and knowledge. For example, Quillen (2004) found a positive relationship between mathematics beliefs and mathematics content knowledge. In addition, in his 2007 study, Philipp argued that the relationship between belief and knowledge should be considered. In terms of confidence, the participants' MKT self-efficacy beliefs mediate the effect of their self-assessment on to their practices (Ross and Bruce, 2007). The discussion of this theme concludes with the observation that growth of MKT and its self-efficacy took place through this theme.

Reshaping Perceptions of Capabilities

The discussion here is supported with narratives from Section 7.3.6. Extracts show a good number of teachers explicitly voicing their increased confidence pertaining to the teaching of arithmetic word problem solving strategies, indicating an increase in self-efficacy (Bandura, 1991). This is observed in the illustrative case of Beatrix when she talks about her ability to help the learners to be competent in solving word problems. This finding is consistent with that of Utley et al. (2005) who found increased teaching efficacy beliefs in the pre-service mathematics teachers after their PD programme. York-Barr et al. (2006) explain that reflective practice promotes teaching efficacy. Thoonen et al. (2011) found that teachers' high sense of teaching efficacy beliefs was a determining factor in their experimentation with RP. The influence of RP was highly noticeable in the 'Self-confidence in teaching mathematics' sub-category (Table 7.5 in Appendix 29). Teachers' high level of teaching efficacy has been linked to effective teaching (e.g. Tschannen-Moran and Hoy, 2007; Aydin, 2019). The teachers in this research made positive statements regarding their teaching efficacy beliefs and confidence (e.g. Hana's, Tilly's and Zak's cases in Section Section 7.3.6). However, there was one case of a teacher struggling with her confidence to teach mathematics (e.g. Marla's case, in Section 7.3.6) because she was never trained as a mathematics teacher. The findings suggest that RP influences considerable growth and change in the teachers, leading to a sense of self-efficacy as evidenced in Sections 6.4.2 and 7.3.6. A high sense of self-efficacy enables the teachers to make practical use of their new MKT (Jones, 2009). Such change and growth allow the teachers to teach differently with new knowledge. The teachers expressed a stronger belief and confidence in their ability to teach arithmetic word problem solving strategies in more productive ways (e.g. Hana, Andria, Libby and Karin). Yeh (2006) found that efficacy beliefs and self-confidence could be improved through teacher reflection; thus, linking Theme 1 to Theme 3. Kupari (2003) explains that teachers' beliefs are important for the implementation of teaching and learning. It was not within the scope of this study to verify if the change in teaching efficacy beliefs impacts significantly with a change in the MKT. Nevertheless, there were parallel growths in both MKT sub-domains and MKT self-efficacy as shown in Sections 6.3.6 and 6.4.3.

Professional and Experiential Knowledge Growth for Change

Masingila et al. (2018) explain that the teaching of problem-solving strategies hinges on constructivist principles. In the case of this study, the teachers are learners undergoing active and experiential learning (Desimone, 2009). This theme focuses on "the mathematical knowledge used to carry out the work of teaching mathematics" (Ball et al., 2008:395). The theme was rated more highly by the participants in comparison to other themes. Narratives supporting this theme are found in Section 7.3.7. The content of the themes indicates that somehow RP affects the teachers' mathematical knowledge and skills. This theme reveals that teachers in the study generally referred to a type of positive change in their professional knowledge. Mezirow (1991) frames this phase as "acquisition of new knowledge". Other researchers have previously found that RP facilitates the enhancement as well as the development of new knowledge (e.g. Ching-shu Shen, 2015; Slade et al., 2019). Based on the number of references identified within this theme, there was enough evidence to conclude that the MKT sub-domain and MKT self-efficacy of the teachers were being heavily reprocessed. In their reflective journals and interviews the teachers referred to various aspects of MKT sub-domains and MKT self-efficacy. The referred knowledge types were classified as CCK, SCK, KCS, KCT and their narratives are well supported with findings from the quantitative analysis chapter (e.g. Figure 6.3) showing over time increase in all the five types of MKT self-efficacy beliefs. For example, we can see Beatrix and Azuza in Section 7.3.7 expressing change in their KCT. However, the teachers experienced the interaction of RP on their MKT differently. For some of them, as they scrutinised their practices through the journals, it convinced them to change their mathematical teaching beliefs, thus leading to change in their practices and in the pupil outcomes, which aligns with the adopted conceptual framework (e.g. Desimone, 2009). We see this in the cases of Erika, Azuza, Andria and Karin in Section 7.3.7. This finding reflects those of Siswono and Hartono (2019) who also found that beliefs, knowledge, and teaching practice are three interdependent factors which determine the quality of a teacher's mathematical problem-solving strategies. This finding is also consistent with that of Guskey's (2002) model of teacher change and that of Swars et al. (2018) where provision of professional development led to change in teacher beliefs. On the other hand, other participants changed their practices as they progressively experimented with the PIES strategy (e.g. Erika and Azuza) and as they expressed changes in their CCK and SCK. Swars et al. (2018) recently observed that a shift in elementary teachers MKT (e.g. SCK, CCK) provided greater opportunities for them to learn. More recently, González and Deal (2019) found evidence of teacher change in three types of teacher mathematical knowledge, notably SCK, KCS, and KCT, through reflective lesson study. Significantly, the features of the five types of mathematical knowledge were not too apparent in the participants' first weekly journals, but the features emerged and became clearer in their next journals as they became more mature in their reflective writing. It is important to note that one particular teacher (Fumi) said that RP had not influentially affected her teaching (see Section 7.3.7). One potential explanation is that the intervention time was too short to impact on some teachers. Contributions from this theme suggest that RP could help the primary teacher to develop the five types of MKT considered in this study notably, CCK, SCK, KCS, KCT and KC.

The importance of this theme to the study and to the wider literature is that previous studies have made associations between MKT, instructional quality, and pupil gain. For example, Hill et al. (2008) found that MKT relates to teachers' mathematical quality of instruction. Similarly, Hill et al. (2005); Rockoff et al. (2011); Baumert et al. (2010) and Ngo (2012) found enough evidence to correlate pupils' learning gains to teachers' MKT, mostly PCK (e.g. KCS and KCT).

Awareness of Practice and Self-knowledge

'Awareness of practice and self-knowledge' was identified as a theme. Narratives supporting this theme are found in Section 7.3.8. As the participants shaped up their perceptions of capabilities, the analysis of data revealed that they became more aware of different aspects of their practices, including self-awareness. This finding was also reported by Hammond-Stoughton (2007) who claimed that RP plays a major role in promoting self-awareness. In their different forms, the teachers put forward the fact that RP has made them more aware of their practices and weaknesses. These are observed in the cases of Nadine, Zak, Andria, where they became more conscious about their teaching and more able to deliver their lessons without doubt or misconception, as Zak explained in Section 7.3.8. Various studies have shown that RP makes the teachers more aware of their practices (e.g. York-Barr et al., 2006; Arthur et al., 2007). There were different nuances of awareness, some being more explicit than others. In this study, the participants' awareness ranged from awareness of professional weakness in practice to awareness of pupils' weaknesses and self-awareness of their feelings. Using Gibbs' (1988) reflective model, a number of the teachers developed awareness of their feelings whenever they came across a critical classroom incident. Awareness is also developed as they reflect on their feelings (Zulfikar and Mujiburrahman, 2018). For example, Zak explains that when working with children the more he feels good, the more he will deliver, and the more the children will understand the concepts.

An important and noteworthy aspect of this theme is that most of the participants recognise they are now more aware of teaching and learning issues. This result is in accord with recent studies by Parra et al. (2016) indicating that reflective teachers become more aware of the social context of their teaching. The significance and contribution of this theme of awareness to the research questions and the overall study is that the MKT and self-efficacy of the teachers develops further as they become more aware of themselves, their teaching, and the pupils' needs, as expressed by the participants in this study. For example, it is evident from their narratives that as the teachers became aware of their pupils individual learning needs, they designed questions that engaged the pupils in their own learning; thus, allowing the teacher to develop further their KCT and KCS. This finding was also reported by Ní Shúilleabháin (2015b). Kim (2013:234) explains that MKT "includes specific illustrations and explicit discussion of the awareness that mathematicians have". For example, awareness of good practice means that the teacher would need to have enough PCK to understand and implement effective teaching.

Therefore, being aware of something comes with its own types of knowledge. In other words, the participants' MKT (e.g. KCT, KCS SCK, CCK, and Knowledge of Curriculum) and self-efficacy are expected to change further with their increased awareness. Quite recently, a study by Kaya et al. (2015) found that teachers who were more aware of pupil-centred teaching spent less time on teacher-centred activities. The teachers in this study are also more aware of their own professional development needs (e.g. Hana, Section 7.3.8). Lastly, they are more conscious of the teaching and learning of individual pupils and of their weaknesses. In summary, the effect of RP on MKT through this theme makes the teachers more aware which led to further change in their MKT, and self-efficacy beliefs. Therefore, awareness is a construct in this study, which works with other themes to impact on the MKT and self-efficacy of the teachers.

Changes in Teaching and Learning

As the participants reflected on their practices, most of them were able to identify a particular problem with their teaching (Kwon and Orrill, 2007). They could also relate to particular positive transformations that were happening in relation to that problem, especially in the final stages of the intervention. This can be seen as a transformation from 'dilemma' cases to 'aha! moments' This is characterised as 'experimentation with roles' (Mezirow, 1991). This was evident in the types of teaching activities they were trying to implement, and in the 'aha! moments' in the classrooms. Their data were unravelled into 'stories' under the theme 'Changes in teaching and learning'. This theme is about the participants associating themselves with surprise pedagogical changes within themselves, their teaching, and their pupils; and such changes were considered as weaknesses at the outset of the intervention. The theme reveals the transformation of the teachers in their practices, through their various experiences. This is evidenced in the narratives of Nadine and Erika about 'Changes in teaching practice' in Section 7.3.9. For example, Nadine explained that the whole intervention was an eye-opening experience for her. These stories confirm the hypothesised conceptual framework of the study (see Figure 4.1), where the model predicts change in instructional practice, in terms of use of increased knowledge, clarity of instruction and a more supportive climate. These findings reflect those of Kramer (2018) who also found that teachers who engaged in RP ultimately brought changes to their instructional practices and thus to the learning outcomes of their pupils. Similarly, Kelcey et al. (2019) found important correlations between knowledge, classroom instruction, and achievement in their study of primary teachers in the USA. In contrast, Piasta et al. (2015) found no significant effects of professional development on classroom instruction. A key finding in this theme is that the teachers also became better designers of learning, and their teaching became more 'dialogic' (Alexander, 2020); which is evidenced in Hana's narrative when trying to engage with and make sense of their teaching tasks. The teachers were also able to prepare better learning activities for their pupils. In a number of instances, the breakthrough occurred after they were able to break down the main learning activities into a series of small tasks, which are text-book examples of scaffolding, thus showing evidence of MKT self-efficacy development. This finding was also reported by Watson and De Geest (2012) who found that underachieving pupils were able to improve through scaffolding. The teachers also developed into better assessors of their teaching activities and got to know their pupils a lot more, as in the cases of Andria and Karin, which is evidence of MKT development (e.g. KCT and KCS).

Creating Student-centred Learning Environments

This theme is the culmination of Theme 1 and the Seven -theme Framework (see Section 8.3). It is also in theoretical relationship with previous stages of the conceptual framework (see Figure 4.1). It involves caring for the pupils by personally engaging with them, while the pupils were active participants in their new approaches. This theme is supported with narratives from Section 7.3.10 about being aware that the pupils can create their own knowledge if they are well guided. That is, the conceptual framework (Figure 4.1) hypothesised that any change in the teachers would lead to change in instructional practice of the teacher; this would then lead to change in the learning outcomes of the pupils. The analysis of the qualitative data shows that the teachers gradually shifted their teaching from being teacher-centred to a better planned, interactive, and pupil-centred environment (e.g. the case of Beatrix, in Section 7.3.10, where she explained that her teaching had “become more pupil-centred”). This includes taking up a more discursive approach to the teaching of mathematics, with a greater focus on pupil needs (Blanton et al., 2005; Blumberg, 2015; Polly et al., 2017), and giving them responsibility for their own learning. This finding is consistent with that of Polly et al. (2017), who found through their year-long PD programme that the kindergarten teachers implemented more pupil-centred instruction and incorporated more pupil-centred beliefs about mathematics teaching after getting involved in RP. Such findings are consistent with sociocultural learning perspectives. Blumberg (2015) explains that critical reflection helps teachers to transit their practice from teacher-centred to pupil-centred approaches. The finding is also consistent with the study of Lebak and Tinsley (2010) who found that teachers engaging in reflective practice changed their classroom practice from teacher-centred to pupil-centred. This theme reveals transformative effects of reflection on both teaching and learning approaches. There are various cases of change in the pupils as they learn new mathematics, as express by Andria, Zak and Harriet. The pupils were more engaged with the tasks, as in the cases of Andria, Zak and Nadine as evidenced in the sub-theme ‘students more engaged with tasks’. Changing from teacher-centred to pupil-centred is a clear change of a teacher’s belief system, as in the cases of Erika, Beatrix and Zak. A study conducted by Isikoglu et al. (2009) showed that in-service teachers held positive beliefs about pupil-centred teaching. Previous studies have also shown that teachers' teaching strategies are associated with their pedagogical beliefs (Minor et al., 2002). The student-centred environment is a principle of the social constructivist epistemology (MacLeod et al., 2018). Taking up such a learning approach by the teachers would mean a higher manifestation of the teachers' MKT and teaching efficacy beliefs, which would have been inspired by the social constructivist learning theory. Such implementation would include an improved sense of MKT (e.g. SMK and PCK) as in the cases of Bryony and Andria as they co-constructed their knowledge through collaborative enquiry (section 7.3.10). In effect, the teachers validated their teaching ideas with that of the pupils. This is what Bandura (1991) means by the importance of social influences on one's self-efficacy beliefs. Such a learning environment is often created by the teacher introducing the class to stimulative conceptual ideas that the pupils would need to investigate further, either individually or in groups. The teachers articulated various aspects of the constructivist learning theory environment they wanted to implement, as in the case of Vignette as she planned to make her pupils explain their reasoning in small groups to one another. The findings also reveal that the impacts on the teachers were translated into the classroom, and the pupils were better able to understand the solving of arithmetic word problems. Such findings corroborate those of Chamberlin (2009). The findings also imply that promoting pupil-centred learning is an appropriate approach to tackle pupils' learning difficulties with word problems. The change to MKT sub-domains in this theme is seen through its sub-category names. The interpretations of the sub-categories suggest that after participating in RP, the participants favoured a more constructivist approach to the teaching of mathematics. Such interpretation is consistent with the findings of Ren and Smith (2013). In a course designed to increase the MKT of teachers they found the teaching beliefs of teachers inclined towards the pupil centred. A shift from teacher-centred to pupil-centred teaching would require an educative change in their belief systems, MKT, and self-efficacy. Through this theme, there was evidence of teacher and pupils actively co-constructing their learning. To conclude, the quantitative results reveal significant growth in the teachers' MKT self-efficacy beliefs scores over time (Table 6.12), and the qualitative data suggest growth in both MKT sub-domains and MKT self-efficacy beliefs. The findings reveal that over the course of the intervention, the teachers modified their MKT self-efficacy beliefs. Both of these constructs are important for the effective teaching of mathematics. Researchers (e.g. Tschannen-Moran et al., 2008) argue that teachers' instructional quality can be determined by the development of their teaching efficacy beliefs.

8.2.7 MTSE Enhancement in the Quantitative and Qualitative Data (RQ3 and RQ5)

This study envisaged that the RP treatment would enhance the mathematics teaching efficacy beliefs of the participants. This section answers the third and fifth research questions.

The participants MTSE was their self-perceived ability to generally teach their pupils arithmetic word problem solving strategies (Bandura, 1977). The findings revealed that there was no statistically significant difference between the intervention and control group teachers in terms of their MTSE levels (see Section 6.5.3).

However, a majority of the participants believed they were more self-efficacious to teach arithmetic word problem strategies after the intervention (see Table 8.3 in Appendix 36). The belief in being more self-efficacious was supported by the quantitative data analysis that reported an increase of 5.7% of the intervention group, compared to 1.6 % of the control group (see Table 6.13). Thus, the DiD test in Table 6.14 shows that there was an over time increase in the MTSE level of the intervention group compared to the control group. There are a variety of reasons why the RP treatment may have affected the teachers' mathematics teaching self-efficacy. One possible explanation could be found in Hana's interview. She commented that she had never understood how to properly address problem solving. This research was a safe environment for the teachers to learn through trial and error. Once Hana had understood problem solving, this would have enhanced her confidence, and thus her mathematics teaching self-efficacy. This is consistent with the study conducted by Briley (2012) who found mathematical beliefs were statistically significant predictors of MTSE for elementary pre-service teachers. Several narratives from previous themes reported experimenting with new strategies and learning from them.

Bandura (1997) explains that in order to enhance self-efficacy one should use the sources of efficacy information. Bandura mentions the four sources of efficacy beliefs as: mastery experiences, vicarious experiences, verbal persuasion, and physiological responses. 'Mastery experiences' in this study is defined as the positive experiences of a participant in performing a successful teaching task. Therefore, it is arguable that the examples of Hana, Harriet and Azuza, are cases of mastery experiences where they have acquired new knowledge of how to better teach word problem solving (see Table 8.1 in Appendix 34). This could have been the source of the self-efficacy for those participants. This perception is consistent with that of Palmer (2011). In an intervention study, Palmer found that mastery experience was a source which enhanced the science-teaching self-efficacy of twelve elementary teachers. Therefore, in line with Guskey's (2002) and Desimone's (2009) PD framework the participants' achievement of self-efficacy could also be attributed to trial and error where they keep the strategies that worked and produced changes in pupil learning outcomes; thus, increasing their self-confidence (Guskey, 2002). Kitsantas and Baylor (2001) found that reflection inspires teachers to re-address their teaching efficacy beliefs about lesson planning. Swars et al. (2007) found a strong relationship between MTSE and effective teaching. Also, Thoonen et al. (2011) and Depaepe and König (2018) found teaching efficacy impacting on instructional practices and pupils' learning outcomes. The critical reflective approach taken by the participants was a major step in reshaping their beliefs and ultimately their MTSE. Therefore, bringing the seven-theme framework into perspective, it is argued that the increase over time in MTSE can be attributed to most of the seven variables (e.g. themes) in the framework. Therefore, they are all considered as potential MTSE predictors.

8.2.8 The Participants Self-efficacy Beliefs Through the Lens of Guskey's Model

Improving teacher efficacy, or teachers' belief in their abilities and capacities to perform tasks that will change the learning outcomes of their pupils, is one of the determining factors of classroom success. This is because teachers' attitudes and beliefs influence their sense of self-efficacy, which in turn influences their classroom practices and pupil outcomes (e.g. Harootunian and Yargar, 1980; Clarke and Hollingsworth, 2002; Guskey, 2002; Malmberg et al., 2014). Such sense of efficacy of the participants was demonstrated in the way they engaged with the pupils and in their teaching strategies and processes. Guskey's (2002) teacher development model presents the visible evidence that change in teachers' beliefs and attitudes may come only as a result of improvement in their pupils' learning outcomes (see Figure 4.1). Teachers need to see the impact of their teaching on the learning outcomes of the pupils before they change their belief systems. The model is relevant to this study because evidence from the participants' 'stories' showed that their self-efficacy beliefs changed after experiencing success in the learning outcome of their pupils. For example, this was seen in the extract from Andria:

> *Next time I will try more complicated problems. This is, to challenge the high ability students. For me to see if they have understood it well. Individual problems will be assigned to check their level of understanding. I started to change the negative aspect about this PIES and try to make it work to see what the results holds. Little by little I can see progress. Now time will tell.*
>
> [**Andria**, Interview]

The teachers became more efficacious after the change in learning outcomes of their pupils as a result of being involved in this intervention study (Ross, 1998; Kast et al., 2021). Also, in some cases, rather than significant change to learning outcomes, the participants witnessed changes in pupils' engagement, and responses to the teaching, which corroborated with the findings of Stes and Van Petegem (2013). Evidence from this current study suggests that the participants changed their belief systems after having changed their practices and observed the outcomes of their pupils (Ross, 1998; Guskey, 2002). During the intervention, the participants developed sufficient self-efficacy perception of pupils' achievement which allowed them to select appropriate instructional strategies, provide a conducive learning environment and sufficient learning experience, and took responsibility for pupils' achievement. As an analytical model, Guskey's model shows that the participants' success 'stories' and 'aha moments' are direct proof of the efficacy of RP in changing the self-efficacy beliefs of teachers, and a sure way for the MOE to assess the effectiveness of its investments in the schools. This research provides empirical evidence in supporting Guskey's model.

8.2.9 Application of Other Reflection Models

Several researchers have investigated and found significant positive relationships between reflective teaching, critical reflection, self-efficacy and pupils' achievement (e.g. Babaei and Abednia, 2016; Rahimi and Weisi, 2018; Kramer, 2018; Depaepe and König, 2018). Reflective practice allows teachers to develop more positive beliefs about their efficacy (Babaei and Abednia, 2016); and the process also considers the teachers' assumptions, self-beliefs and practices. As stated in section 3.4.6, various models or aspects of those models could have been used to frame the reflective practice of the participants. Particularly, alongside Gibbs' (1988) reflective practice model and Kolb's (1984) learning cycle**;** Brookfield's (1995, 2017) four lenses of critical reflection model also provides further insight into teachers 'hunting assumptions' (Brookfield 1995: 28) and their opening themselves up to new perspectives as they critically reflected on their practice; in terms of what went well and what might need to be further improved or changed (Brookfield, 2017). The four lenses are autobiographies as teachers and learners, students' eyes, colleagues' perceptions, and theoretical literature. The framework allows critical reflection on teaching practice to be offered in order to develop awareness of the pedagogic assumptions and self-efficacy beliefs that lie behind their teaching (Brookfield, 2017). The autobiographical experience through the teachers and learners' lens is teachers self-reflecting and examining their personal experience and knowledge as learners in order to understand how people learn so that they can provide their pupils with a better learning experience. When reflecting on their past experiences as learners, there were cases where the participants tried to avoid reproducing the humiliations they had faced as learners themselves, and instead implemented things that inspired them, as in the case of Harriet. This was an opportunity for her to correct her autobiographical lens:

> *For example, my maths teacher which I won't mention name, the way she taught word problem, if I were to follow the same path, I would be killing*

> *so many pupils. The good thing is that I am having a positive mind and I want to make a change. I feel that teachers from back can have enormous impact on the young teachers. This is it until you want to make a change, then the same history will repeat itself. Unless you make a change, you will destroy people's enthusiasm about mathematics. Then I want to change that.*
>
> [**Harriet**, Interview]

The students' eyes or lens is about seeing their views on how they are experiencing learning, and a way to "deconstruct traditional power dynamics and relationships that stultify critical inquiry" (Brookfield, 2017:89). Put differently, learning from your students is like having a "critical friend" who would tell you things about your teaching that maybe you would not like to hear. Azuza said this when asked about what RP has brought to her MKT:

> *What I am thinking about right now is concept and the pedagogy part also. There is not only one way of teaching mathematics, and you can actually learn from your student also. So, this is what I have gained about this.*
>
> [**Azuza**, Interview]

It was an opportunity to examine herself through her pupils' perspectives and to know them much better, and to learn from them and as well as getting more academic insight of their true abilities that could inform her reflection. In this study there were numerous cases of the teachers receiving critical feedback from their pupils, such as in the cases of Azuza and Hana. The colleagues' perception lens allows the teachers to see their practice through the eyes of a critical friend, especially when coming across disorienting dilemmas. Such friends should allow the teachers to check on their assumptions and open up to new ideas about the problem (Brookfield, 2017). Acting as critical friends allows the teachers to see their classroom challenges differently, but to share them with colleagues rather than hiding them, such as the cases of Hana (section 7.3.5) and Azusa. This was again described by Azuza in the following extract when explaining what she meant by improved confidence:

> *Ya. I did not have the….. Most of the time when I would teach a subject, I would go to the Internet prior to just check or go check with other teachers, that now I do more. So, this is how like my confidence. Now I don't not have to say like, they would be saying things about me because I do not know much about this subject. So, if you do not know*

you just need to go out there and ask. My confidence of asking when I do not know has changed greatly.

[**Azuza**, Interview]

The fact that Azuza had only four years of teaching experience, colleagues' perceptions helped to re-frame her assumptions about teaching through critical reflection. The theoretical literature lens involves teachers reflecting on their assumptions and their practice by reading narratives of teaching which should help them to switch their interpretive frame and pedagogic assumptions. This helped them to reflect on the complexity of pedagogical encounters (Britzman,1991). That is, they should not blame themselves totally for their pupils' underachievement in mathematics after understanding from reading the literature that there could be various interpretations of their current situation. Picking up the theoretical literature lens could have helped Karin to find support and comfort when reflecting on her classroom dilemma:

Sometimes we complain of pupils not learning, but we do not usual look at us to see why pupils are not learning. I do reflect on my way of teaching as well. Even if I have a difficult class, I said that there could be something wrong with my teaching too because maybe; Why are those could and this one could not? Maybe I could give more time for those. How would I do that?

[**Karin**, Interview]

Taken together, Gibbs' and Brookfield's reflective models are examples of other reflective-practice frameworks which are useful in helping teachers to reflect on assumptions and enhance their self-beliefs in order to make important, real-time decisions in their classroom and contribute valid knowledge about teaching word problem solving. That is, reflective teaching models and teachers' self-efficacy beliefs have the potential to work together to improve classroom practice.

8.2.10 Development of the Teaching Assistants

In the early chapters issues were raised about untrained Teaching Assistants (TAs) working in mainstream classrooms in Seychelles. Rather than giving support to teachers (e.g. whole-class responsibility TAs), they are being used as fully-fledged expert teachers to teach mathematics in the primary classrooms due the acute shortage of trained teachers. That is, their roles have become instructional, and they are now making pedagogical decisions. Hence, the comments raised cast doubt on the effectiveness of their contributions towards mathematics education and quantitative improvement in the learning of pupils (Higgins et al., 2011; Symes and Humphrey, 2011; Graves, 2011;

Sharples, Webster and Blatchford, 2015). The findings of this study suggest that TAs could also be given continuing professional development (CPD) so that they can also benefit from RP which can improve their classroom practice that could eventually impact positively on pupils' learning outcomes (Guskey, 2002; Desimone, 2009; Lushen, Kim, and Reid, 2012). In the participants' 'stories' there were claims of their professional knowledge and skills in word problems being developed, as well as an increased self-awareness, and a sense of commitment with their teaching and pupils. There were also calls for further training as exemplified by Charlotte:

> *So, if us teachers get the training on the different methods that have been evolved in the teaching of mathematics and how to use these methods in the class, I think the mathematics results will improve in Seychelles, as it is a problem now. Every year after year the mathematics national exam is not good. Maybe if we get the chance to get some training, maybe it will improve for the betterment of our country and our schools.*
>
> [**Charlotte**, Interview]

Charlotte had the confidence and conviction that further training would enable teachers to support learning more effectively and improve the teaching of mathematics in Seychelles. Even if Charlotte was not a TA, the findings from this study suggest that RP should enable TAs to extend and update their professional knowledge, skills, and self-efficacy beyond their current limitations as seen in the narrative from Karin:

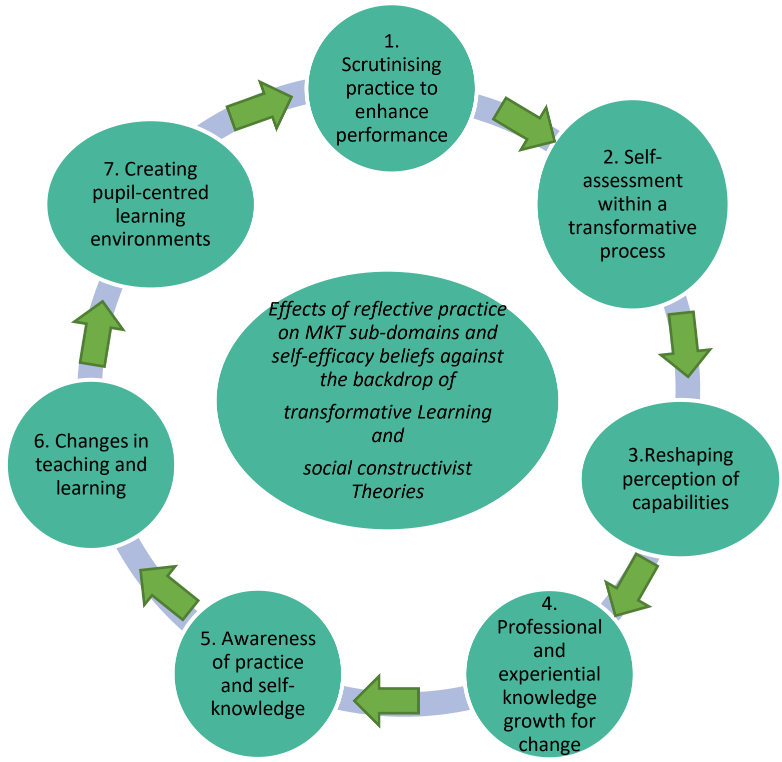
> *Again, it has helped me to reflect more, to look at it more deeply, more critical, and to be positive also in it. It makes you better off in how to go about in your teaching after what you have taught especially ending a topic, especially if there is re-teaching or re-testing.*
>
> [**Karin**, Interview]

Both Charlotte and Karin understood RP as a mechanism that can transform their thinking processes and practice; and seminal in supporting their professional development. That is, RP within CPD should be seen as an effective approach to develop TAs professionally; and thus, improve pupils' mathematics learning outcomes. Also, the narratives of the participants contain levels of criticality in their reflections, which is further evidence of their professional development. TAs can be effectively trained to make a significance difference in the mathematics learning outcomes of pupils in Seychelles. The fact that it is quite unlikely that the use of TAs in Seychelles will decrease in future, due to the acute teacher shortage, then the training and development of TAs is of extreme importance. Evidence from this study suggests that if TAs are to be successful in supporting learning and helping schools to improve the mathematics learning outcomes of pupils in Seychelles, then RP is the mechanism for the enhancement of their MKT and self-efficacy beliefs. While waiting for formal training (Sherin, 2002), RP can provide TAs with new thinking space that could nurture their professional development.

8.3 The Seven-theme Framework for Teachers' MKT and Self-efficacy Growth

The findings in this study have led to an original conceptual framework for framing the development of MKT sub-domains and self-efficacy of primary teachers. All the seven major themes substantially capture meaning from the data in order to answer the research questions. The themes contain important required elements for positive change in MKT and self-efficacy of the teachers. Figure 8.2 makes a formal presentation of the new conceptual framework for the professional development of teachers. In numerical order, Figure 8.2 shows the relationship between the major themes and provides connections for successful growth in MKT and mathematics teaching self-efficacy within an RP framework. The framework is reflective based, cyclical in nature, and provides links between the seven themes.

Figure 8.2: The Seven-Cycle Theme Framework of MKT and Self-efficacy Growth



The seven themes cyclically connect to each other to tell the 'stories' of the professional-development experiences of the teacher. However, it is important to note that the connecting themes do not have well-defined boundaries. The themes relate and connect to each other through a chain-reaction process starting with Theme 1 (see Figure 8.2). The sub-themes or sub-categories were derived both inductively from the raw dataset and deductively using the MKT framework (Attride-Stirling, 2001; Nowell et al., 2017). The themes are presented in logical order to further help tell the stories of the participants. The essence of each theme appears to target a social constructivist learning environment for both teachers' and pupils' development, where Theme 4, 'professional and experiential knowledge growth for change', could be an overarching theme. If the framework is showing increment in the teachers' MKT and self-efficacy over time (Chapter 6 results), then, it is suggesting that its thematic components work together to implement knowledge and efficacy growth in teachers.

Guided by the TLT framework, RP empowered the conceptual framework of this study as a three-stage process of professional development of the teachers; framed as transformative, informative, and generative.

8.3.1 Reflective Practice as Transformative, Informative and Generative

The purpose of the PD was to transform the teachers' practices, and the first three themes initialise this process. Figure 8.2 depicts RP as transformative. Within these first three themes of the framework, the teachers undergo a critical reflective process in their experiential learning and try to understand what they are going through. This involves assessing and reshaping their beliefs and assumptions, in order to change their perceptions of classroom incidents. Such an initialisation stage is grounded within the socio-constructivist framework and the platform from which the teachers can learn (Cirocki and Farrell, 2017). Furthermore, this stage starts to shape up their self-efficacy. This is supported by their actions in the classrooms such as the modification of their teaching strategies. From Theme 4 to Theme 5, RP is depicted as being informative. Through these themes, the teachers complete a re-constructive and transformative process of their new realisations, thus experiencing transformation in knowledge. Themes 1 to 3 shape their mathematics perception in the light of current practices. This stage enables them to acquire new practical knowledge (Mezirow, 1991) and then pick up new information about themselves, pupils and practices. As discussed in Section 8.2.5, the teachers become more aware of different aspects of their practices, and their behaviour towards their pupils. Themes 6 and 7 depict the generative nature of RP as being a "generative powerhouse" of knowledge building and leading to "change in the world" (Jones, 2009:19; Brookfield, 1995:227). This is where the teachers apply their new realisations in terms of knowledge and efficacy to move their instructional practices and pupils forward in order to experience growth over time. Therefore, this framework puts the effects of RP on MKT and mathematics self-efficacy in new perspectives and provides interesting insights into the teachers' practices. The practical benefit of this framework is that it presents RP with its thematic and interacting components that lead to change in teachers' MKT and self-efficacy. In practical terms, the framework informs the practitioner what RP entails, and is a guide to richer and more effective reflection. Therefore, it is argued that the framework could be effective in guiding the primary teachers' professional growth in the Seychelles' context for the development of their MKT and self-efficacy beliefs.

8.3.2 The Reduction Effect in Sample Size of the Control Group

In their 2007 study, Valentine and McHugh found student-level attrition being reported in 119 out of 367 randomised education experiments. The reduction in sample size of the control group during the intervention in this current study was a cause of concern for the researcher. This would normally contribute to statistical errors and biases in quantitative studies and threaten the robustness of findings (Antrobus et al., 2014). That is, it could compromise the statistical significance and external validity of the study, making the findings less precise, and prevent them from being generalised or influence the statistical power of the study. Such attrition can prevent any existing difference between the groups to be detected, or really knowing whether there is no difference between the groups. The control group size decreased from forty-one to thirty-one participants for the MKT pre-post-tests, and from forty-five to twenty-five participants for the pre-post-intervention questionnaires. However, both reductions are within the accepted minimum sample size range for t-tests if the population is normally distributed (see section 6.3.2). Therefore, the statistical significance of the study has not been compromised to a great extent. On the other hand, based on the adopted interpretive paradigm, the aim of this research was not to generalise the findings over the population (Lichtman, 2011; Thomas 2017), and the attrition group did not differ greatly from the experimental group in terms of baseline characteristics to introduce serious biases and distort the findings. Moreover, based on the interpretive stance of the study, the use of the DiD estimator and the 'stories' of the participants; any attrition bias introduced by reduction in the control group participants is likely to have led to underestimation of the effect of reflective practice on the MKT and self-efficacy beliefs of the participants.

8.4 A Typology of Teachers' Self-efficacy Growth

This section relates to Research Questions 1 and 3 and explores further the extent of the development of the teachers' self-efficacy. However, to better understand the development of the teachers' self-efficacy over time, a review of the dataset was conducted in the light of the participants' engagement with RP. The chain of narrative evidence for this section is found in Table 8.1 (see Appendix 34).

The teachers' similarity in their self-efficacy growth experience is based on Bandura's (1997) four broad sources of self-efficacy (see Section, 3.4.13 and Appendix 35). That is, the teachers used four different, but overlapping sources of self-efficacy information to inform their word problem solving teaching skills. It is worth noting that earlier cluster analysis suggested the presence of four groups of teachers (see Table 6.15). These self-efficacy sources are mastery experiences, vicarious experiences, verbal persuasion, and physiological responses (Bandura, 1997). However, these topologies are not as neat and orderly as they appear in Table 8.1 (see Appendix 34). Some of the participants (i.e. Azuza, Hana) could be placed in different categories because they have different versions of the same 'story' and have different sources of self-efficacy.

The Mastery Experience Cases

This group is examined through the experiences of Hana, Harriet, Azuza, Fumi, Karin, Andria, Nadine and Zak. As discussed in Section 3.4.13, 'Mastery experience' is about the role of their past successes, personal accomplishments, failures and personal experiences in enhancing or diminishing self-efficacy. Bandura (1977) and Pfitzner-Eden (2016) explain that mastery experience is the most powerful source of information for self-efficacy. In the midst of classroom challenges, these teachers experienced enhancement of self-efficacy through previous successful classroom experiences. Almost half of the teachers (see Table 8.2 in Appendix 35) look to their prior classroom achievements to strengthen their self-efficacy, which led to enhancement in their MKT. As depicted in Table 8.1, this is the largest category, with a wide range of participants, irrespective of their cluster analysis allocation (see Table 6.15). The typology is grounded in data and based on the themes that have been identified from the dataset. Various sources of mastery experience were expressed by the participants in this group (see Table 8.1 in Appendix 34). These were: teaching experience, attitudes towards teaching, subject knowledge, confidence, passion for teaching, innovative approaches, and teaching competence. For example, Hana explained that from her experience of teaching problem solving, she used stories rather than pictures. From that experience it was then easier to replace the stories with pictures which enabled her to successfully implement the new PIES strategy, thus enhancing her confidence. 'Attitudes towards teaching' was one of the sources of mastery experience for Harriet. She argued that, despite challenges, her primary focus had always been on the performance of the pupils rather than the requests of the school management. This attitude has enabled her to keep on improving in the field. Azuza was the least experienced participant, but the most highly trained. She used both competence and confidence as sources for mastery experience. Azuza explained that when she was first introduced to the PIES strategy, she wanted to try it out with her pupils; and the outcome was successful. Both Azuza and Harriet were totally committed to their teaching and RP. Also, several participants expressed change in their confidence. For example, Azuza explained that she was now more confident and efficacious about consulting her colleagues. Like the case of Hana, Fumi used her twenty-four years of experience of teaching as a source for mastery experience. Fumi was able to find similarity between the strategy she had been using and the newly introduced PIES strategy. This similarity had enabled her to successfully embrace and implement RP.

After twenty-six years of service, Karin was still passionate and had confidence in her teaching. Karin used at least two of these sources to confront new challenges in her teaching in order to develop her practice. Karin expressed confidence in her teaching and was ready to take up challenges. From the field notes, it was noted that Andria (a foreign teacher) implemented innovative approaches to her teaching compared to the local teachers (i.e. scaffolding the learning materials). These approaches ranged from teaching techniques to classroom management. She explained that the pupils should be “given the opportunity to express their understanding according to their way of learning”. Such a perspective influenced her teaching techniques as well. In the case of Andria her mastery experience was derived from most of the sources depicted in Table 8.1, which she claimed made a marked difference in her teaching. Nadine employed teaching experience, subject knowledge and self-confidence as sources for her performance accomplishments. Her teaching experience enabled her to address the needs of the low achievers as well. She stated that she created her own problems to fit the lesson and the pupils were able to solve the word problems. Her use of working instructional strategies was evidence of mastery experience. Zak was very much concerned with his professional development which relates to his teaching competence and emotional exhaustion. That is, Zak realised that his strong base of self-efficacy (e.g. mastery experience) was deteriorating. Zak’s level of self-efficacy and teaching performance caused him concern for the future effectiveness of his teaching. In conclusion, it is argued that successful past experiences of the participants remain the most pervasive influence on their self-efficacy. This group viewed both successful and unsuccessful experiences as opportunities to learn and engage with RP.

The Vicarious Experience Cases

The second grouping is ‘vicarious experience’ or social learning and is represented by Erika, Beatrix and Charlotte. As noted earlier, vicarious experience is achieved by observing examples of others or comparing oneself with others while they are performing “threatening activities without adverse effect” (Bandura, 1977:197). Put differently, watching others successfully perform, this group of teachers developed their self-efficacy and MKT by comparing their performance with others as well as learning from the success ‘stories’ of others. In the context of teaching, vicarious experience could involve classroom observation of an experienced teacher by a beginning teacher. There was evidence of vicarious learning among all the three cases in this group. However, for each of the three teachers their source of vicarious experience was collegial support, which plays a vital role in the professional development of teachers, as well as watching of YouTube videos where model teachers are using effective teaching approaches (Bautista, 2011). Some important benefits of collegiality among teachers are growth, development, and professionalism (Shah, 2012). There were success stories of the application of PIES across the dataset (e.g. Azuza, Table 8.1 in Appendix 34). However, Beatrix appeared to have little experience of how to help the eleven pupils who had difficulties with problem solving (see Table 8.1). Therefore, seeking help from colleagues was one of the options for her and the other participants. Erika learnt from mentors as well as from her colleagues and wished that such collegial support would continue. It is worth noting that, in a number of instances, the participants mentioned that vicarious learning came by observing the pupils successfully performing the tasks (e.g. Charlotte). This makes the theoretical connection between teachers' sense of efficacy, teachers' knowledge, and pupils' achievement, which are depicted by Desimone's (2009) conceptual framework being used in this study (see Figure 4.1). A number of studies made the connection between teachers' efficacy and pupils' learning outcomes (e.g. Klassen and Tze, 2014). Therefore, collegial support and vicarious learning from pupils were sources of efficacy for teachers in this category.

The Verbal Persuasion Cases

The teachers in this category increased their self-efficacy through 'Verbal persuasion' or social persuasion. That is, if the teachers receive realistic encouragement from the school management, they are more likely to be less doubtful of their performance on a particular task (Bandura, 1997). In the context of teaching, verbal persuasion can convince teachers of their capabilities, especially if the persuasion comes from a more experienced teacher (e.g. a mentor). However, verbal persuasion is also seen as a weak source of self-efficacy information. In this category, Vignette, Libby and Tilly can be taken as examples. The three teachers are disturbed by their own limitations, and also by the weaknesses of their pupils. We see the interesting case of Vignette (see Table 8.1) who required the assistance of other teachers to discuss her mistakes after realising her professional weaknesses, as seen through her journal writing. On the other hand, Libby's case is an example of where the PD workshop conducted for this research was seen as a type of mentor and source for her self-efficacy information. Even if verbal persuasion is less effective as a self-efficacy source compared with mastery experience and vicarious experience (Morris et al., 2017), the participants saw the PD workshop as a credible source of verbal persuasion. Tilly's case is also another example of verbal persuasion. Her persuaders were parents and school management, and a closer look at her 'stories' reveals some element of self-talk as a source of self-efficacy. They were all influential on the choices she made and will continue to make in the future. Based on her narrative, parents and school management convinced Tilly to take on the overwhelming challenge of managing the children's behaviour so that learning could take place. At the time of interview, verbal persuasion was influential enough to keep Tilly in the profession.

The Physiological Response Cases

Bryony, Zara and Marla represent the ‘Physiological response’ group, where there can be seen cases of physiological arousal or emotional arousal. Teaching appeared to be an emotional experience for these participants. Physiological arousal is a source of self-efficacy. Teacher efficacy relates to the psychological and emotional conditions of teachers (Collie, Shapka, and Perry, 2012). That is, teachers expressed confidence about their performance of tasks through feelings, emotions, or sensations. Teachers are less likely to expect success in their classes when they are frustrated and agitated as in the case of Bryony, Zara and Marla. All three teachers expressed initial states of frustration (see Table 8.1) when their pupils did not perform to their expectations. Marla was angry with herself because she perceived that she approached her teaching wrongly and the pupils could not understand. An interesting aspect of the physiological response cases is the fact that the phrase “I was happy” was used seventeen times and “I was angry” was used six times by the participants across the dataset. This suggests that this typology could be the most common after mastery experience.

Based on the emergent four broad categories of teachers, it is fair to state that, in some ways, the above neat typology could misrepresent reality and be biased against the complex world of teachers constructing their professional knowledge. For example, a teacher can subscribe to more than one category. However, the choice of category allocation is grounded in the data and was a way to organise all the responses. It is argued that all four sources of self-efficacy are salient for the teachers. It is inferred that the teachers used the four sources of self-efficacy to teach word problem solving strategies. Klassen and Tze (2014) explain that self-efficacy beliefs could be developed through PD settings while paying attention to the above four categories. This typology contributes a model of professional development that deliberately targets self-efficacy growth in terms of mastery experiences, verbal persuasion, vicarious experience and physiological response for in-service primary mathematics teachers. That is, the teachers must be given opportunities to be exposed to competent models of teaching, as well as models that support or encourage other teachers. This typology continues to support the findings in this study that RP positively influences mathematics teaching self-efficacy growth. In conclusion, this typology does not just categorise the teachers, but also supports Bandura's (1997) theory that self-efficacy is acquired through mastery experience, vicarious experience, verbal persuasion and physiological responses.

8.5 A Framework for Enhancing Ball et al.’s (2008) MKT Sub-domains

Taken together, the findings of this study contribute towards a proposed conceptual framework which the mathematics community can use to understand and guide teachers in their PD in the area of MKT growth and self-efficacy growth (see Figure 8.4). The thesis argues that the MKT of teachers can be developed by reflecting on appropriate learning tasks designed to change the way their pupils learn mathematics in terms of more fruitful outcomes. This proposed framework allows for the identification of aspects of MKT and its self-efficacy beliefs developed by the teachers through RP. The findings build on the seminal work of Ball et al. (2008) and bring new insights into teachers' MKT development through RP. Ball et al. (2008) developed the MKT framework which describes the knowledge required to teach primary mathematics but have not indicated how such knowledge is involved in reflecting on the teaching of mathematics (Van den Kieboom, 2013). Therefore, from the themes generated within this research, and the subsequent findings, it is proposed that the landmark work of Ball et al.'s (2008) MKT framework is extended to include the interacting variables as agents of change as depicted in Figure 8.4. Through RP, the teachers' current MKT interacts with the identified interacting variables to bring further changes in their mathematical knowledge for teaching. Ball et al.'s (2008) MKT framework is used as a template to develop a conceptual framework to hold the interacting variables identified in this study. Therefore, a framework is proposed for conceptualising the development of MKT. The researcher suggests that this extended framework could be used to theorise and guide the professional development of teachers in both teacher training institutions and in schools; as well as to frame a discussion around the type of variables interacting with RP to develop the MKT of teachers. Figure 8.4 is another major contribution of this study to the literature of MKT. The framework also reveals interesting insights into the development of the teachers and their self-efficacy. It depicts a conceptual framework that includes the interacting variables that culminate in enhanced MKT and mathematics teaching self-efficacy through RP.

Figure 8.3: Ball et al. (2008) MKT Framework

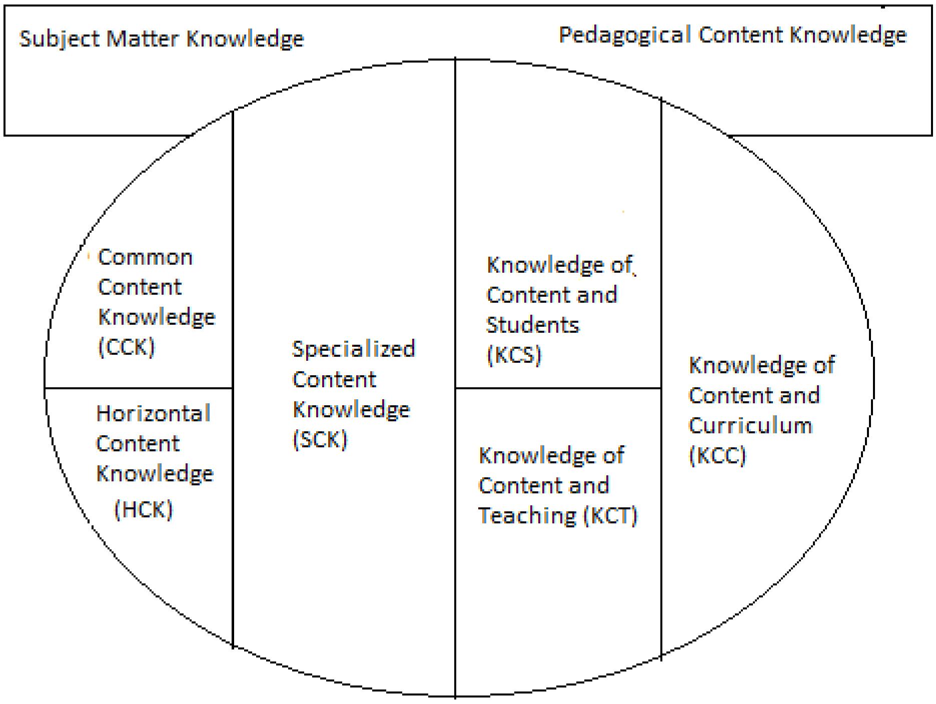
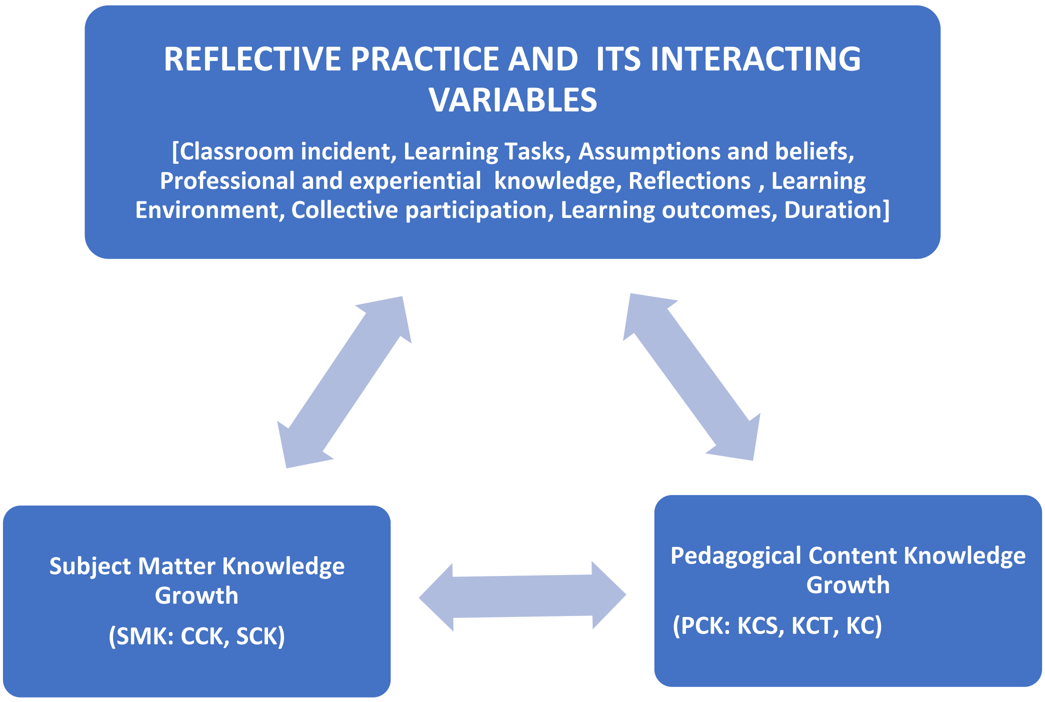


Figure 8.3 presents Ball et al. (2008) original MKT framework and Figure 8.4 is a proposed framework for improving teachers' MKT growth and self-efficacy through RP.

Figure 8.4: A Proposed Framework for Teachers' MKT Growth and Self-Efficacy through RP



Based on the findings of this research, the conceptual framework contributes to the MKT literature by suggesting RP interacts with *Classroom Incident, Learning Tasks, Assumptions and Beliefs, Professional and Experiential Knowledge, Reflections, Learning*

Environment, Collective Participation, Learning Outcomes, and Duration to bring changes to the MKT sub-domains of the teachers.

8.6 Chapter Summary

This chapter presents a comparative account of the findings that emerged from the data analysis. The findings were interpreted and discussed in the light of the research questions. Looking at the comments provided by the teachers through the theoretical frameworks, most of them seemed to be expressing a sense of empowerment, growth and transformation in both their MKT, self-efficacy and teaching practices. Most of the seventeen participants discussed ways in which they benefited from this intervention study. The experiences were common across participants. The analysed data provided evidence of growth over time in the teachers' MKT and self-efficacy. It is argued that such growth was triggered by the participants critically reflecting on their practices to change understanding, beliefs and patterns of teaching. There were both similarities and differences in the way the participants experienced RP. The discussion in this chapter has shown that teachers engaging in RP could be impacted in several ways. Such impact was guided and explained through a seven-theme framework. When considering both the quantitative and qualitative data analysis, the key findings suggest that RP has a positive influence over time on the MKT sub-domains, MKT self-efficacy and MTSE beliefs of in-service primary teachers in Seychelles. There have been important over time contributions of RP towards the development of the teachers' MKT and self-efficacy in this study. The findings demonstrated positive over time effects of RP on the five MKT sub-domains (e.g. CCK, SCK, KCT, KCS and Knowledge of Curriculum) considered in this study; as well as the mathematics teaching efficacy beliefs of primary teachers pertaining to the teaching of arithmetic word problem solving strategies. The quantitative analysis did not approve statistically significant changes in all the results (except for one); but rather showed promising over time changes. Both the quantitative and qualitative data sets provided convincing evidence of positive change in participants at the end of the intervention. The study also provided evidence of the benefits of RP transcending teachers' limitations and affecting pupils' learning. The findings of this research are consistent with what was envisaged by both the theoretical and conceptual frameworks in terms of transforming teachers' knowledge and their practices (e.g. Vykotsky, 1978; Mezirow, 1991**;** Desimone, 2009). Most of the participants spoke of the increased benefits of RP in terms of its effect on their affective domains, knowledge, teaching and learning, as opposed to its drawbacks. It is worth noting that the analysis of the quantitative data revealed that RP did not significantly affect the MKT sub-domains and MTSE of the teachers but made significant change to their MKT self-efficacy. The failure to reach statistical significance suggests that educational change is challenging, complex and requires commitment. Based on Kolb’s (1984) Experiential learning model in Section 3.4.7, human learning and development takes time, and similarly the information-processing theory informs us that people take time to process new information. The gradual development of teachers’ MKT was observed in Ding’s (2016) study. In the light of the way this study has been designed, and its ultimate results, it can be argued that a more sustained RP could bear a similar study with more fruitful findings in terms of significance. Although the findings in this thesis cannot be generalised, in-service teachers in Seychelles and elsewhere can benefit from this study in terms of its practicality and promising results. The next chapter concludes this thesis.

Chapter 9: Conclusions

9.1 Introduction

The previous chapters examined the effects of reflective practice on mathematical knowledge for teaching (MKT) sub-domains, MKT self-efficacy beliefs, and mathematics teaching self-efficacy (MTSE) beliefs of primary teachers in Seychelles. After the introduction, this chapter is organised into nine sections. Section 9.1 makes a summary of the research. Section 9.2 provides a summary of the study. Section 9.3 makes a summary of the research findings. Section 9.4 presents the contributions to knowledge. Section 9.5 acknowledges the limitations of the research. Section 9.6 considers the recommendations for policy and practice. Section 9.7 considers the recommendations for further research. The penultimate section overviews the professional development of the researcher, and Section 9.9 draws concluding remarks.

9.2 Summary of the Study

This thesis reports the findings of a quasi-experimental multiple case study of seventeen teachers reflecting on their practices in order to improve their MKT and self-efficacy beliefs. As discussed in Chapters 1 and 2**,** Seychelles has had a history of underachievement of its pupils in primary mathematics. This prevalence of underachievement has been a source of concern for many stakeholders. In view of this, I felt that one way to alleviate this educational crisis and stagnation was by investigating whether the MKT and self-efficacy beliefs of the primary teachers could be enhanced. Despite the importance of reflective practice (RP) in education, there are few to no studies relating to what extent it can enhance the MKT sub-domains and self-efficacy beliefs of primary teachers. The five types of MKT considered in this research are Common Content Knowledge (CCK), Specialised Content Knowledge (SCK), Knowledge of Content and Student (KCS), Knowledge of Content and Teaching (KCT) and Knowledge of Curriculum (Ball et al., 2008). After having identified related factors from literature in Chapter 3, I designed a quasi-experimental multiple case study with intervention and control groups. The participant teachers in the intervention group underwent RP treatment in the teaching of arithmetic word problem solving for ten consecutive weeks. Each of the participants in the intervention group reflected on their teaching using Gibbs' (1988) reflective model, and articulated ways in which RP impacted on their teaching of word problem solving. Data were collected using pre-post MKT tests, MKT self-efficacy questionnaires, interviews, and reflective journals, in the domain of arithmetic word problem solving strategies. Drawing upon the adopted conceptual framework of effective professional development (see Chapter 4, Desimone's 2009 framework), it was necessary to focus the RP intervention (e.g. professional development) on a curriculum area. Thus, arithmetic word problem solving strategies was the chosen area. The overarching research question is: *To* *what extent does reflective practice change the MKT sub-domains, MKT self-efficacy beliefs, and MTSE beliefs of primary teachers pertaining to the teaching of arithmetic word problem solving strategies?*

The study sought to answer the overarching research question using the following five sub-questions:

1. To what extent do the MKT sub-domains and MKT self-efficacy beliefs of primary teachers develop after engaging in RP?
2. Is there a statistically significant difference between the MKT sub-domain scores of the intervention and control groups after engaging in RP?
3. To what extent does the MTSE level of primary teachers change after engaging in RP?
4. Is there a statistically significant difference between the MKT self-efficacy beliefs of the intervention group and control group after engaging in RP?
5. Is there a statistically significant difference between the MTSE level of the intervention and control groups after engaging in RP?

9.3 Summary of Findings

The research involved an intervention group and a control group. Both groups took a pre-MKT test, post-MKT test, as well as completing pre-intervention and post-intervention questionnaires. The intervention participants reflected on their practices, completed weekly reflective journals, and were also interviewed. In relation to the research objectives (see Section 1.3.1) and the above sub-research questions, the research produced the following findings which are outlined in the next section.

9.3.1 Effects of RP on MKT Sub-domains

Data were analysed to determine if any significant differences existed between the intervention group and the control group pertaining to their Mathematical Knowledge For Teaching (MKT) sub-domains. With no pre-test differences between groups, the findings of this study revealed that participants in the intervention group, who were exposed to RP, did not have significantly higher scores in their MKT sub-domain test than those in the control group. An independent samples t-test showed that there was no statistically significant difference between the intervention and the control groups of in-service teachers in their MKT sub-domain test scores, thus not in favour of the intervention group. One potential explanation of the failure to reach statistically significant results was the limited period of the intervention; and this was also raised by participants in the intervention group. However, a Difference in Differences (DiD) estimator was used to estimate the intervention effects by overriding confounding variables. This provided mathematical evidence of over time change in the MKT sub-domains of the intervention group after engaging in RP. This finding suggests that RP could help in-service primary teachers to develop their MKT sub-domains if they continue reflecting on their practices. The quantitative part of this study is crucial because its findings, (e.g. the DiD result) provide empirical evidence in support of RP as potential agent for MKT enhancement.

Concerning the interpretation of the qualitative aspect of the study, I used the interpretivist paradigm and drew upon the adopted conceptual framework of Desimone (2009) for an effective professional-development framework to frame the discussions in the participants' self-narratives. I also applied the social constructivist theory of Vygotsky (1978), and the transformative learning theory (TLT) of Mezirow (1991) to explain how the teachers make meaning out of their classroom experiences to enhance their own mathematical knowledge and the pupils' learning. The consistent findings emerging from the thematic analysis of the reflective journals, interviews and open-ended items show that the intervention group's MKT sub-domains experienced over time growth during their involvement in the RP compared to the control group. This was identified through seven common themes from the data, which were shared by the teachers (see section 7.3.3). These illuminated themes suggest that RP did have positive effects on the teachers' MKT sub-domains for teaching arithmetic word problem solving. Significantly, through the aforementioned themes, most of the participants in the intervention group explicitly professed a type of growth in their MKT sub-domains, while two of them perceived that significant growth would, hopefully, happen in the near future due to the short time frame of this study. The latter two cases further support the DiD results which showed over time change in the MKT sub-domains. The study revealed that the teachers used the intervention opportunity to critically re-examine their classroom practices from different perspectives using different types of reflecting strategy. Mostly, all the teachers grasped the importance of critically scrutinising their practice in order to bring change to their own teaching and to enhance their pupils' learning. Evidence from the study showed that a change of beliefs and attitudes of the teachers though critical reflection was necessary for change to start happening (Reynolds et al., 2014), and this was central to their professional knowledge development. There were cases of the teachers having a more positive attitude towards their teaching and better understanding of how children learn to solve arithmetic word problems. There were signs of change in their mathematical beliefs. The changes in their perspectives and belief systems led them to adopt pupil-centred instruction where they demonstrated more care for their pupils. The teachers applied social-constructivist principles and transformed their teaching into dialogues and scaffolds (Harnett, 2012). The over time increase in both the MKT and self-efficacy of the teachers would suggest that there is an association between these two dependent variables. However, this is beyond the scope of this study.

In summary, the teachers in this study engaged mostly in individual RP to assess their teaching and the pupils' learning, which led to positive change in their MKT word problem solving strategies. From the findings, it is appropriate to suggest that if the in-service teachers are nurtured effectively through RP, they could significantly improve their MKT, as indicated in this study as well as in existing studies (e.g. Palmer, 2011). Other empirical studies on RP and teachers' MKT have also reported change in the teachers' MKT (e.g. Ching-shu Shen, 2015; Ní Shúilleabháin, 2015b; Leavy and Hourigan, 2016; Slade et al., 2019), but notably in KCS and KCT. I argue that findings from this research are likely to hold in the same setting as well as other settings under the same conditions.

9.3.2 Effects of RP on MKT Self-efficacy Beliefs

With regards to their MKT self-efficacy beliefs to teach arithmetic word problem solving, the findings of this study revealed that the intervention group, which was exposed to RP, had significantly higher scores than the control group. An independent samples t-test showed there was a significant difference in the MKT self-efficacy beliefs mean scores between the intervention and control groups. A paired-samples t-test was performed on the data to compare the difference between the MKT self-efficacy mean before and after the intervention for the intervention group. The result was statistically significant (see Section 6.4.2). Such a finding is important because self-efficacy is related to pupil learning outcomes in mathematics (e.g. Khan, 2012; Peters, 2013). This provides the answer to Research Question 4. Specifically, the teachers' self-efficacy for KCT, KCT, SCK, CCK and knowledge of curriculum improved significantly after engaging in RP. The finding was further supported by the DiD estimator of intervention effects which showed an over time increase in the MKT self-efficacy beliefs scores of the intervention group. Such findings show that RP can make teachers feel more confident in their practices.

In terms of qualitative analysis, RP made the teachers more efficacious by validating their MKT for teaching word problem solving strategies. That is, there was an increase in explicit voicing of confidence in their ability to help their pupils with arithmetic word problem solving strategies in relation to MKT in more productive ways. Therefore, the findings of this study show that RP supports teachers' development of MKT self-efficacy beliefs towards the teaching of word problem solving strategies. The significance of this finding is that it would have been challenging for the teachers to implement gains in their MKT without positive growth in their MKT self-efficacy beliefs to influence their instructions.

9.3.3 Effects of RP on MTSE Beliefs

With regard to MTSE beliefs, this was the teachers' self-perceived ability to generally teach their pupils arithmetic word problem solving (Bandura, 1977). The findings from the independent samples t-test revealed that there was no statistically significant difference between the intervention and control groups. However, the DiD estimator showed that the intervention group increased their MTSE belief scores by 0.18 points because of the RP intervention. In view of the two different groups of results for self-efficacy in this study, the overall findings suggest that the teachers expressed encouraging perceptions of their new capabilities to teach word problem solving strategies. In summary, the qualitative and quantitative data analysis from this study revealed the teachers' MKT sub-domains, MKT self-efficacy and MTSE beliefs were positively influenced by RP.

The integration of quantitative and qualitative data in this educational research made important contributions to the study in terms of informed conversation and negotiated accounts of findings to improve educational policies and classroom practices, as stated in the objectives of this study. As stipulated in Chapter 5, the mixed-methods approach has given the study a greater depth of understanding, which would have not been possible if I had used a single methodology of investigation. This study has shown that RP has positive over time effects on all the mathematical knowledge types investigated in the research, which are required to effectively teach primary mathematics; as well as on the mathematics self-efficacy beliefs of the teachers pertaining to the teaching of arithmetic word problem solving strategies. The conclusions drawn make the design of this study a suitable approach to researching similar educational phenomena. The case-study teachers were able to give their pupils a fresh start by changing their mathematics learning experience as evidenced in the various themes and excerpts in this study. Long-term exposure to the teaching and learning approach used in this research should bring more results that are fruitful to both the teachers and the pupils.

9.4 Original Contributions to Knowledge

This research is significant because it has made important contributions to MKT and self-efficacy literature. The study is original because it is the first study on MKT and self-efficacy in Seychelles. The findings and approaches of this research make empirical, methodological, and theoretical contributions to the field of MKT and self-efficacy pertaining to the teaching of arithmetic word problem solving strategies. More specifically, the research contributes and advances knowledge to different partners in the mathematics-education communities. Firstly, this research makes an original and major contribution to knowledge in the field of MKT by providing support to, and extending on, previous studies (e.g. Bargiband et al., 2016; Leavy and Hourigan, 2016; Slade et al., 2019; Kuennen and Beam, 2020) to suggest that the use of RP has the potential to enhance mostly all MKT sub-domains, together with their self-efficacy beliefs.

Secondly, it makes an original contribution to knowledge in the field of MKT by providing a framework for how the MKT sub-domains of the teachers are enhanced. Working in the socio-cultural tradition, the inductive approach to the qualitative data analysis produced an extended model of Ball et al.'s (2008) framework (Figure 8.4) which is to conceptualise the development of the teachers' MKT. This framework is useful for teacher training institutions to "inform the design of support materials for teachers" (Kuennen and Beam, 2020:772); similarly in schools, to revamp the development of MKT sub-domains and MKT self-efficacy beliefs of teachers. The interactive variables within the framework were the mechanisms within this research through which the MKT sub-domains and MKT self-efficacy beliefs of the participants were enhanced. All the interacting variables are inextricably linked to tell a comprehensive story of change and provide a candid picture of the teachers interacting with their environment to change their professional knowledge and self-efficacy beliefs. The framework features interacting variables working together to affect the teachers' MKT and self-efficacy in separate ways. Connecting this proposed framework with Ball et al.'s (2008) MKT framework gives new insight into the development of teachers' MKT.

Thirdly, this research also makes a major theoretical contribution to Bandura's (1997) self-efficacy theory. Through a typology of teachers' self-efficacy growth through RP, this study supports and strengthens Bandura's (1997) claim that mastery experiences, vicarious experiences, verbal persuasion and physiological responses are sources of self-efficacy beliefs (see Section 8.4). The contribution of the typology to Bandura's (1997) theory is that RP as a high-impact pedagogy has the potential to sharpen teachers' self-efficacy beliefs as identified in Section 3.4.13. The study shows how self-efficacy beliefs of the teachers are linked to the teachers' level of confidence in their MKT; and the findings of the study suggest that RP has the potential to change teachers' mathematics self-efficacy beliefs in relation to their MKT in solving word problems. Therefore, in the context of Seychelles, school leaders could give attention to teachers' self-efficacy beliefs, for they make important contributions to pupils' achievement.

This study also advances knowledge across multiple fields and locations. The originality and uniqueness of this study is that it extends the literature on MKT and self-efficacy beliefs to the context of SIDS. To the knowledge of the researcher, this is the only SIDS research on MKT so far. Also, it is the first study in Seychelles that has investigated and documented the MKT and mathematics teaching self-efficacy of in-service primary teachers. Therefore, this study makes a direct contribution to the mathematics education system in Seychelles and offers some important findings in the context of SIDS, which could be used as a foundation for further research. Also, the researcher was not able to find other studies which have both answered the questions posed and used a similar research design to the one in this current study. Therefore, this study makes unique contributions to MKT literature at both national and international levels. The methodological contribution (Desimone, 2009; Hill et al., 2013) is provided by the unique integration of quasi-experimental and inductive designs to conduct this study. Such methodological contribution has proven useful in expanding our understanding of the usefulness in the integration of different research paradigms.

9.5 Limitations and Challenges of the Research

This research has some limitations, which should be considered when interpreting the findings. Firstly, the research was conducted in a limited time frame of ten weeks which was too short for the full effects of the intervention to take place. In addition, although the paradigm stance of the study does not call for generalisation, a larger sample size for the intervention group would have made the quantitative results slightly more reliable in terms of outcome. Also, the small convenience sample size may have influenced the result of the study. Within the boundary of the interpretive paradigm, the purpose of this study was not to generalise the findings (Bailey, 2018; Mason, 2018). And, indeed, generalising findings from educational research is a challenge because, very often, research has a context that renders it not appropriate in other settings. Nevertheless, the fact that the purpose of the quantitative result was to support the qualitative findings, a larger sample of participants for the intervention group would have perhaps produced better inferential statistical estimates. Another limitation was homogeneity of the case-study sample. The cases were mostly female participants except for one male. This limitation is typical of primary schools in Seychelles where the teacher population is mostly females; and the teaching of young children is probably perceived as 'a gendered activity' (Forrester, 2005:271). However, Cueto et al., in their 2017 study, found that male teachers' PCK was positively associated with pupil achievement. Another limitation is that the researcher recognises that the MKT tests and self-efficacy questionnaires cannot capture the complete knowledge change of the participants. Also, all the experimental group participants were voluntary cases, rather than randomly selected cases. Therefore, it may be that the experimental group participants responded differently to the research than those who were in the control groups. The researcher recognises that at times it has been a challenge to fully recognise, distinguish and categorise the different types of MKT in the participants' narratives due to theoretical overlapping (Ball et al., 2008), especially when it comes to SCK, KCT and KCT. Therefore, some of the participants' comments could have fitted all the three categories. Lastly, a detailed case study of everyone would have brought more depth and richness to this study; but it would have been quite lengthy to provide a comprehensive narrative for each of the seventeen teachers. Another limitation is the small post-intervention increment of the control group, which could be due to the Hawthorne effect. That is, the control group's awareness of being studied.

The main challenges in this study are perhaps around whether the intervention and control groups were properly and reliably implementing the intervention activities. It was difficult to confirm if all the teachers were indeed conducting follow ups of their action plans as expressed in their weekly journals, and in the workshop, and as emphasised in Gibbs' (1998) reflective model. If not, then this could have impacted on their genuine attempts to change their MKT, self-efficacy and the pupils' learning, thus impacting on the findings of the study.

9.6 Recommendations for Policy and Practice

This research contributes towards the development of MKT and self-efficacy beliefs of teachers in Seychelles. Policy makers and educationists in Seychelles need experimental evidence upon which they can introduce reforms to enhance the MKT and self-efficacy of teachers; so that in return they can improve the educational attainment and market skills of the workforce. The findings of this study indicate that primary-school teachers can use RP to enhance their five types of MKT, as well as to change their mathematics self-efficacy beliefs, especially while they are waiting for more formal training. Equally important, the study has shown that the teachers can change their classroom practices with very little training, if they are willing to change their pre-conceived perspectives. The findings indicate that teachers need to reflect on their teaching in order to understand its diverse aspects. Primary mathematics teachers are 'failing' in their practices because they very often lack understanding of how to make learning happen during challenges. The teachers need a progressive pedagogy that can move them from 'dilemma' cases to 'aha! moments' in their classrooms. Such progressive pedagogy could involve a collaborative and collegial environment as evidenced in this study, where the teachers engaged their pupils in various activities in order to build new experiences and develop effective mathematical abilities through shared mathematical understanding. Collegial environment is important for teacher change because a teacher's mindset can impede reflection (Knowles et al., 2014). The findings of this study suggest that if primary mathematics teachers are given enough time to implement and take a reflective, practice-based approach to their teaching, they may well expect to see changes to their professional knowledge, confidence, and the improved learning outcomes of their pupils. In practice, this can be facilitated through an established framework at school level, where the teachers are being reflective throughout the school and meet regularly for interactive discussions. In the light of the findings of this study, it is suggested that teachers need to trust PD programmes and engage in continuing RP to improve their MKT and enhance self-efficacy. As their courses are re-designed, it is recommended that the pre-service teachers are trained in the use of the reflective journal as a tool for PD. More specifically, I suggest that the interactive conceptual framework for MKT sub-domains development (Figure 8.5), and the typology of teachers' self-efficacy growth (Section 8.4), are considered when implementing PD for mathematics teachers. Teachers should be able to be involved in mastery experiences, vicarious experiences, verbal persuasions and physiological responses. This could become feasible by making schools aware of local research findings in mathematics education in Seychelles when considering the PD of teachers.

9.7 Recommendations for Future Research

Apart from the related factors considered in the educational interventions described in this study, other factors need to be investigated for future research. This intervention study was conducted over a period of ten weeks. The findings were positive, but some were not significant enough. Therefore, it is suggested that if this study was to be replicated, more time should be allocated to it, or that a longitudinal design is used to further understand how the teachers' MKT and self-efficacy change over time. The findings of this study suggest that there might be a strong associative effect of RP on the five types of MKT and self-efficacy beliefs pertaining to the teaching of arithmetic word problem solving strategies, which did not have strong statistical evidence in this current study. Therefore, a clear implication for future research is that more intervention studies need to be developed to further test the proposed conceptual framework for teacher knowledge development proposed in this study. However, this current study should also move on to consider RP as a collegial process and investigate how discourse and dialogue impact on the development of MKT and self-efficacy of the teachers (Harnett, 2012; Smith and Stein, 2011; Golding, 2017). Furthermore, further research is required to determine if a participant must go through all the seven thematic stages to experience change in their MKT sub-domains and self-efficacy (see Figure 8.2). Also, additional research is needed to further explore how teachers' perception of their capabilities influences their MKT. Due to the limited timescale of this study and the fact that the DiD estimator used suggests that the expected changes require more time, it would be interesting to conduct the same study using a larger time span. Future research is required that would determine a much longer time effect of RP on MKT and self-efficacy beliefs of primary teachers.

9.8 Professional Development of the Researcher

Six years ago, I embarked on this research journey as a novice researcher, a mathematics teacher, teacher trainer, parent and someone who wanted reforms in the mathematical knowledge of primary school teachers in Seychelles. Furthermore, I wanted to improve my professional and academic capabilities. Now ‘bending back’, I realise that I have learnt a lot about research in general, and more specifically educational research. It reminds me of the words of my first principal supervisor who wrote that “Educational research endeavours to examine educational phenomena, to learn from them and to improve existing knowledge, policy and practice” (Basit, 2010:1). This study has positively extended and contributed to the seminal work of Ball et al. (2008) in the context of Seychelles as a SIDS. The study has contributed much to the Seychelles context, and on issues which no other research has examined. As a mathematics teacher, I have achieved a lot through this research, especially through the ten-week fieldwork with the teachers. I have come a long way pertaining to the conduct of research and have grown as an academic. Now I see much more than just what I have chosen to study. I also see myself in the research process. I am not a fully-fledged researcher yet, but the research skills and knowledge I have accumulated through this study have equipped me to take up any research challenge. When I reflect on my research journey, it makes me realise that the ending of this study gives birth to the start of my career as a researcher, and I am ready to revive and contribute to the educational research community in Seychelles. I have already successfully supervised my first Master’s degree pupil at the University of Seychelles in conjunction with the University of the West of Scotland (UWS) using the knowledge and skills I have gathered through this PhD journey. Even if this current research area becomes outdated in a few years, my research skills will live on.

9.9 Concluding Remarks

Altogether, this research demonstrated the extent to which RP changed the MKT sub-domains, MKT self-efficacy and MTSE beliefs of primary teachers pertaining to the teaching of arithmetic word problem solving. Evidence from this research suggests that the teachers’ understanding of word problem solving is better integrated with their MKT than before. The findings of this study support the adopted conceptual framework and is concordant with previous research. In this study, participants reported several benefits of using RP and reflective journaling to enhance their MKT and self-efficacy beliefs. This study is significant because gains in teacher knowledge and growth in self-efficacy beliefs may improve the mathematical learning outcomes of pupils in Seychelles. Also, the significance and originality of this research means that it provides, for the first time, understanding of how RP works to positively influence the MKT sub-domains of Ball et al.’s (2008) seminal framework. This is a major and original contribution to the MKT literature both at the national and international level. Both MKT and self-efficacy of the teachers began to take shape through RP. The strongest point of this study is to have shown that under certain conditions, RP could improve the MKT and self-efficacy beliefs of teachers. The study has shown that RP provides rich learning opportunities for teachers to enhance their MKT and self-efficacy. The study also indicated that RP develops teachers' MKT and self-efficacy beliefs over time. In practical terms, the teachers agreed that RP improved the way they were teaching arithmetic word problem solving. Using RP to enhance the teachers' MKT and self-efficacy led them to critically reflect on their practices, redefine their beliefs, reconsider their assumptions, self-assess, and reshape their perceptions, become more aware of issues related to their teaching, increase their knowledge and become more inclined towards pupil-centred teaching.

However, the results also show that implementing expected educational change is a difficult and challenging task because the expected outcomes require time. The time factor (PD duration) is a feature of effective PD which was discussed in Section 4.2.1. In this study, the literature (Section 4.2.1), mathematical analyses (e.g. difference in differences), and the participants (e.g. Fumi's Interview, Section 7.3.7) all agree that longer duration of the PD would have made a positive change in the teachers' MKT more tangible. The research has contributed to the understanding of the effects of RP intervention within the context of primary school teachers facing educational challenges in SIDS like Seychelles. Overall, this research strengthens the idea that RP can be used as a tool to extend on the seminal work of Ball et al. (2008) and advance the knowledge base on the influence of RP on self-efficacy. Most significantly, the research has contributed to theory and knowledge through a proposed framework depicting the interacting effects of RP with other variables before converging to enhance MKT and self-efficacy beliefs of teachers, as well as a typology of teachers' self-efficacy growth. The study has also demonstrated that the integration of a quasi-experiment within an inductive design can work together and offer both valuable and reliable evidence of the effects of RP on the MKT and self-efficacy beliefs of teachers in the context of Seychelles. Evidence from this study confirms that professional development in the form of RP can be used as a tool to provide long-term enhancement in the MKT and self-efficacy beliefs of primary teachers in Seychelles; especially while they are awaiting formal training. In the meantime, the findings from this study await practice and readers in Seychelles, especially the teacher training institutions, schools and the mathematics education community.

References

Abdulhamid, L. and Venkat, H. (2014). Research-led development of primary school teachers' mathematical knowledge for teaching: A case study. *Education as Change,* 18(1), pp.137-150.

Abdullah, M.F. and Vimalanadan, L. (2017). Mathematical knowledge for teaching: Making the tacit more explicit in mathematics teacher education. In *AIP Conference Proceedings*, 1847(1), p.030010. AIP Publishing LLC. Available online at: https://doi.org/10.1063/1.4983887 [Accessed on 4th July 2018].

Adu, E.O. and Olaoye, O. (2014). An investigation into some lexical ambiguities in algebra: South African experience*. Mediterranean Journal of Social Sciences*, 5(20), pp.1243-1250.

Ahmad, I., Rauf, M., Rashid, A., Rehman, S. and Salam, M. (2013). Analysis of the problems of primary education system in Pakistan: Critical review of literature. *Academic Research International*, 4(2), pp.324-331.

Ahmed, A.M. (2020). From reluctance to addiction: the impact of reflective journals on Qatari undergraduate pupils' learning. *Reflective Practice*, 21(2), pp.251-270.

Ahn, R. and Class, M. (2011). Student-centered pedagogy: Co-construction of knowledge through pupil-generated midterm exams. *International Journal of Teaching and Learning in Higher Education*, 23(2), pp.269-281.

Alavi, M. and Leidner, D.E. (2002). Knowledge management and knowledge management systems: Conceptual Foundations and Research Issues. *MIS Quarterly,* 25(1), pp.107-136.

Alawi, S.J.S., Shaharanee, I.N.M. and Jamil, J.M. (2017). Profiling Oman education data using data mining approach. In *AIP Conference Proceedings*, 1891 (1), pp.1-6.

Albert, L.R. (2012). *Rhetorical ways of thinking: Vygotskian theory and mathematical learning*. New York: Springer.

Alexander, R. J. (2020). *A dialogic teaching companion*. New York: Routledge.

Alexander, B. (2018). Queer/Quare Theory: Worldmaking methodologies. In: N. Denzin and Y. Lincoln, (eds.), *The Sage Handbook of Qualitative Research,* (5th edn.), p.318. London: Sage Publications.

Alfiani, A.P. and Wulandari, F. A. (2015). Mapping pupil's performance based on data mining approach (a case study). *Agriculture and Agricultural Science Procedia*, 3, pp.173-177.

Allen, J.P., Hafen, C. A., Gregory, A. C., Mikami, A. Y. and Pianta, R. (2015). Enhancing secondary school instruction and pupil achievement: Replication and extension of the My Teaching Partner–Secondary intervention. *Journal of Research on Educational Effectiveness,* 8(4), pp.475-489.

Alsina, Á. and Mulà, I. (2019). Advancing towards a transformational professional competence model through reflective learning and sustainability: The case of mathematics teacher education. *Sustainability*, 11(15), pp.1-17.

Amaele, S. and Okenwa, U. (2018). Bridging the Gap between Behaviourist Theories of Learning and Primary Education Practice. *International Journal of Education and Evaluation*, 4(3), pp.65-71.

Anderson-Levitt, K. (2003*). Local meanings, Global schooling: Anthropology and world culture theory*. New York: Palgrave MacMillan.

Anfara, V.A. and Mertz, N.T. (2006). *Theoretical Frameworks in Qualitative Research*. Thousand Oaks, CA: Sage Publications.

Antrobus, E., Elffers, H., White, G., and Mazerolle, L. (2014). Nonresponse bias in randomized controlled experiments in criminology: Putting the Queensland Community Engagement Trial (QCET) under a microscope. *Evaluation review*, 37(3-4), pp.197-212.

Apple, M. (2001). *Educating the “right” way*. New York: Routledge Falmer.

Arthur, C.S., Miller, R., Thibado, N., Rule, C.A., Dunham, E. and Stoker, J. (2007). Pre-service elementary teachers’ reflective insights from teaching mathematics during an authentic early practicum experience. *Journal of Authentic Learning*, 4(1), pp.43-64.

Ashley, L. (2017). Case Study Research. In: R. Coe, M. Waring, L. Hedges and J. Arthur, (eds.). *Research Methods and Methodologies in Education*, (2nd edn.), pp.114-115, London: Sage Publications.

Ashraf, H. and Zolfaghari, S. (2018). EFL teachers’ assessment literacy and their reflective teaching. *International Journal of Instruction*, 11(1), pp.425-436.

Askew, M., Venkat, H. and Mathews, C. (2012). Coherence and consistency in South African primary mathematics lessons. In T.Y. Tso (eds.), *Proceedings of the 36th Conference of the International Group for the Psychology of Mathematics Education*, 2, pp.27-34.

Aksu, Z., and Kul, U. (2019). The mediating role of mathematics teaching efficacy on the relationships between pedagogical content knowledge and mathematics teaching anxiety. *SAGE Open*, 9(3), pp.1-10.

Atkinson, R.C. (1975). Mnemotechnic in second-language learning. *American Psychologist*, 30(8), pp.821-828.

Attride-Stirling, J. (2001). Thematic networks: an analytic tool for qualitative research. *Qualitative Research*, 1(3), pp.385-405.

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. *Teaching and Teacher Education*, 27(1), pp.10-20.

Aydin, I.S. (2019). Improvement of preservice Turkish teachers’ perceived writing self-efficacy beliefs. *Educational Sciences: Theory and Practice*, 19(1), pp.78-94.

Babaei, M., and Abednia, A. (2016). Reflective teaching and self-efficacy beliefs: Exploring relationships in the context of teaching EFL in Iran. *Australian Journal of Teacher Education*, 41(9).

Bailey, C. (2018). *A guide to qualitative field research*. (3rd edn). Thousand Oaks, CA: Sage Publications.

Ball, D. L., Hill, H.C. and Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator,* 29(1), pp.14-17.

Ball, D.L., Thames, M. H. and Phelps, G. (2008). Content knowledge for teaching. What makes it special. *Journal of Teacher Education*, 59(5), pp.389-407.

Ball, D. and Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (eds.), *Multiple perspectives on the teaching and learning of mathematics* (pp.83-104). Westport, Connecticut: Praeger.

Ball, D.L. and Bass, H. (2009). With an eye on the mathematical horizon: Knowing mathematics for teaching to learners’ mathematical futures. *Paper presented at the 2009 Curtis Center Mathematics and Teaching Conference*. Dortmund: Universitätsbibliothek Dortmund.

Bandi, D. (2016). *Overview and analysis of SACMEQ IV study results*. South Africa DBE Parliament Presentation Paper. Available online at http://pmg-assets.s3-website-eu-west-1.amazonaws.com/160913overview.pdf [Accessed on 14th March, 2019].

Bandura, A. (1991). Social cognitive theory of self-regulation.*Organizational Behaviour and Human Decision Processes,* 50(2), pp.248–287.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review,* 84(2), pp.191-215.

Bandura, A. (1977). *Social Learning Theory*. Englewood Cliffs. NJ: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: the exercise of control*. New York: W.H. Freeman.

Barbour, R. (2008). *Introducing Qualitative Research: a student's guide to the craft of doing qualitative research*. London: Sage Publications.

Bargiband, J., Bell, S. and Berezovski, T. (2016). Guided reflections on mathematical tasks: Fostering MKT in college geometry. In T. Fakawa-Connely, N. Engelke Infante, M. Wawro, and S. Brown (eds.), *Proceedings of the 19th Annual Conference on Research in Undergraduate Mathematics Education,* pp.414-419.

Barlow, A.T. and Cates, J.M. (2006). The impact of problem posing on elementary teachers' beliefs about mathematics and mathematics teaching. *School Science and Mathematics*, 106(2), pp.64-73.

Bartlett, S. and Burton, D. (2016). *Introduction to Education Studies*, (4th edn.). London: Sage Publications.

Barton, B. (2009). Being mathematical, holding mathematics: Further steps in mathematical knowledge for teaching. In R. Huntr, B. Bicknell, and T. Burgess (eds.), *Crossing divides. Proceedings of the 32nd annual conference on Mathematics Education Research Group of Australasia* (pp.3-9). Wellington, New Zealand.

Basit, T.N. (2003). Manual or electronic? The role of coding in qualitative data analysis. *Educational Research*, 45(2), pp.143-154.

Basit, T.N. (1995b). *Educational, social and career aspirations of teenage Muslim girls in Britain: an ethnographic case study*, PhD thesis, Department of Education, University of Cambridge.

Basit, T.N. (2010). *Conducting Research in Educational Contexts*. London: Continuum International Publishing Group.

Bassey, M. (1999). *Case Study Research in Educational settings*. Buckingham: Open University Press.

Bassot, B. (2013). *The reflective journal: Capturing your learning for personal and professional development*. Basingstoke: Palgrave Macmillan.

Bassot, B. (2016). *The reflective practice guide: an interdisciplinary approach to critical reflection*. London: Routledge.

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M. and Tsai, Y.M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and pupil progress. *American Educational Research Journal*, *47*(1), pp.133-180.

Bautista, A. and Ortega-Ruíz, R. (2015). Teacher professional development: International perspectives and approaches. *Psychology, Society and Education*, (3), pp.240-251.

Bautista, N.U. (2011). Investigating the use of vicarious and mastery experiences in influencing early childhood education majors' self-efficacy beliefs. *Journal of Science Teacher Education*, 22(4), pp.333-349.

Bawaneh, A.K., Moumene, A. B. H. and Aldalalah, O. (2020). Gauging the Level of Reflective Teaching Practices among Science Teachers. *International Journal of Instruction*, 13(1), pp.695-712.

Beauchamp, C. (2015). Reflection in teacher education: issues emerging from a review of current literature. *Reflective Practice*, 16(1), pp.123-141.

Begle, E.G. (1979). Critical variables in mathematics education: Findings from a survey of the empirical literature. Washington, DC: *Mathematical Association of America and National Council of Teachers of Mathematics.*

Begle, E.G. (1972). *Teacher knowledge and pupil achievement in algebra. SMSG Reports, No. 9.* Stanford: School Mathematics Study Group. Available online at http://files.eric.ed.gov/fulltext/ED064175.pdf [Accessed on 12th April 2017].

Bell, C.A., Wilson, S.M. and Higgins, T. (2010). Measuring the Effects of Professional Development on Teacher Knowledge: The Case of Developing Mathematical Ideas. *Journal for Research in Mathematics Education*, 41(5), pp.479-512.

Bentham, S. (2004). *A teaching assistants' guide to child development and psychology in the classroom*. London: Routledge Falmer.

BERA. (2018). *Ethical Guidelines for Education Research*. London: British Educational Research Association.

Berg, D. (2009). *For students with math-related disabilities or math difficulties, the successful educational intervention is the same*. Berkeley, CA: Making Math Real Institute.

Bergsteiner, H., Avery, G. and Neumann, R. (2010). Kolb's experiential learning model: critique from a modelling perspective *Studies in Continuing Education*, 32(1), pp.29-46.

Bergsten, C. and Frejd, P. (2019). Preparing pre-service mathematics teachers for STEM education. *An analysis of lesson proposals. ZDM*, 51(6), pp.941-953.

Berk, L.E. and Winsler, A. (1995). *Scaffolding children's learning: Vygotsky and early childhood education.* Washington, DC: National Association for the Education of Young Children.

Beswick, K. (2012). Teachers' beliefs about school mathematics and mathematicians' mathematics and their relationship to practice. *Educational Studies in Mathematics*, 79(1), pp.127-147.

Biesta, G. (2017). Mixing methods in educational research. In: R. Coe, M. Waring, L. Hedges and J. Arthur, (eds.), *Research Methods and Methodologies in Education*, (2nd edn.), p.159. London: Sage Publications.

Biesta, G. (2009). Good education in an age of measurement: On the need to reconnect with the question of purpose in education. Educational Assessment, Evaluation and Accountability. *Journal of Personnel Evaluation in Education*, 21(1), pp.33-46.

Birks, M., Mills, J., Francis, K. and Chapman, Y. (2009). A thousand words paint a picture: The use of storyline in grounded theory research. *Journal of Research in Nursing*, 14(5), pp.405-417.

Black, P. and Plowright, D. (2010). A multi-dimensional model of reflective learning for professional development. *Reflective Practice*, 11(2), pp.245-258.

Blank, R.K. and de las Alas, N. (2009). *Effects of teacher professional development on gains in pupil achievement: How meta-analysis provides scientific evidence useful to education leaders*. Washington, DC: The Council of Chief State School Officers. Available online at : http://www.ccsso.org/content/pdfs/Final%20Meta%20Analysis%20Paper%20full.pdf [Accessed on 6th June, 2017].

Blanton, M., Westbrook, S. and Carter, G. (2005). Using Valsiner's zone theory to interpret teaching practices in mathematics and science classrooms. *Journal of Mathematics Teacher Education*, 8(1), pp.5-33.

Blömeke, S., Olsen, R. V. and Suhl, U. (2016). Relation of pupil achievement to the quality of their teachers and instructional quality. *Teacher quality, instructional quality and pupil outcomes*, (2), pp.21-50.

Blömeke, S., Suhl, U. and Kaiser, G. (2011). Teacher education effectiveness: quality and equity of future primary teachers' mathematics and mathematics pedagogical content knowledge. *Journal of Teacher Education*, 62(2), pp.154-171.

Blumberg, P. (2015). How critical reflection benefits faculty as they implement learner-centered teaching. *New Directions for Teaching and Learning*, (144), pp.87-97.

Boaler, J. (2003). Studying and capturing the complexity of practice: The case of the dance of agency. In N. Pateman, B.J. Dougherty, and J.T. Zilliox (eds.), *Proceedings of the 27th PME International Conference*, 1, pp.3-16. ERIC Clearinghouse.

Bold, T., Filmer, D., Martin, G., Molina, E., Rockmore, C., Stacy, B., Svensson, J. and Wane, W. (2017). *What do teachers know and do? Does it matter? Evidence from primary schools in Africa. Working Paper No. 7956*. Washington, DC: The World Bank.

Bolton, G. (2014). *Reflective Practice: Writing and Professional Development*, (4th edn.). London: Sage Publications.

Bonghanoy, G.B., Sagpang, A P., Alejan Jr, R.A. and Rellon, L.R. (2019). Transformative Professional Development for Mathematics Teachers. *Journal on Mathematics Education*, 10(2), pp.289-302.

Boon, R.T., Urton, K., Gruenke, M., and Rux, T.A. (2019). Mnemonic Strategies in Mathematics Instruction for Students with Learning Disabilities: A Narrative Review. Learning Disabilities: *A Multidisciplinary Journal*, 24(2), pp.49-62.

Borg, S. (2011). Language teacher education. In J. Simpson, *The Routledge Handbook of Applied Linguistic*s. New York: Routledge.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher,* 33(8), pp.3-15.

Borko, H., Eisenhart, M., Brown, C.A., Underhill, R G., Jones, D. and Agard, P.C. (1992). Learning to teach hard mathematics: Do novice teachers and their instructors give up too easily? *Journal for Research in Mathematics Education*, 23(3), pp.194-222.

Boud, D. (2001). Using journal writing to enhance reflective practice. *New Directions for Adult and Continuing Education*, 2001(90), pp.9-18.

Bowie, L., Venkat, H., and Askew, M. (2019). Pre-service Primary Teachers' Mathematical Content Knowledge: An Exploratory Study. *African Journal of Research in Mathematics, Science and Technology Education*, *23*(3), pp.286-297.

Braun, J.A. and Crumpler, T.P. (2004). The social memoir: an analysis of developing reflective ability in a pre-service methods course. *Teaching and Teacher Education*, 20(1), pp.59-75.

Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), pp.77-101.

Braun, V. and Clarke, V. (2013). *Successful qualitative research: a practical guide for beginners*. London: Sage Publications.

Bray, W.S. (2011). A collective case study of the influence of teachers' beliefs and knowledge on error handling practices during class discussion of mathematics. *Journal for Research in Mathematics Education,* 42(1), pp.2-38.

Brigham, F.J., Scruggs, T.E. and Mastropieri, M.A. (2011). Science education and pupils with learning disabilities. *Learning Disabilities Research and Practice*, 26 (4), pp.223-232.

Briley, J.S. (2012). The Relationships among Mathematics Teaching Efficacy, Mathematics Self-Efficacy, and Mathematical Beliefs for Elementary Pre-Service Teachers. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, (5), pp.1-13.

Britzman, D.P. (1991) *Practice Makes Practice: A Critical Study of Learning to Teach*. Albany: State University of New York Press.

Brock S. (2010). Measuring the Importance of Precursor Steps to Transformative Learning. *Adult Education Quarterly*, 60(2), pp.22-142.

Brooke, M. (2014). Developing the reflective practice capabilities of pre-service trainees in TESOL through online means. National University of Singapore. In *4th CELC Symposium Proceedings,* pp.50-60.

Brookfield, S. (2005). *The power of critical theory: Liberating adult learning and teaching*. San Francisco: Jossey-Bass.

Brookfield, S. (1995). *Becoming a critically reflective teacher*. San Francisco: Jossey-Bass.

Brookfield, S. (1999). *Becoming a critically reflective teacher*. San Francisco: Jossey-Bass

Brooks, R., Rielete., K. and Maguire, M. (2014). *Ethics and Education Research*. London: Sage Publications.

Brouwer, J., Jansen, E., Severiens, S. and Meeuwisse, M. (2019). Interaction and belongingness in two pupil-centered learning environments. *International Journal of Educational Research*, (97), pp. 119-130.

Bruun, F. (2013). Elementary teachers' perspectives of mathematics problem solving strategies. *Mathematics Educator*, 23(1), pp.45-59.

Bryant, D.P., Goodwin, M., Bryant, B.R., and Higgins, K. (2003). Vocabulary instruction for students with learning disabilities: A review of the research*. Learning Disability Quarterly*, 26(2), pp.117-128.

Bryman, A. (2016). *Social Research Methods*, (5th edn.). London: Oxford University Press.

Burch, P. (2007). Educational policy and practice from the perspective of institutional theory: Crafting a wider lens. *Educational Researcher*, 36(2), pp.84-95.

Burkman, A. (2012). Preparing Teachers for Success in Elementary Classrooms through Professional Development. *International Journal for Professional Educators,* 78(3), pp.23-34.

Burkhardt, H., and Bell, A. (2007). Problem solving in the United Kingdom. *ZDM*, 39(5-6), pp.395-403.

Burns, R. (2000*). Introduction to Research Methods*, (4th edn.). London: Sage Publications.

Burroughs, N., Gardner, J., Lee, Y., Guo, S., Touitou, I., Jansen, K. and Schmidt, W. (2019). A Review of the Literature on Teacher Effectiveness and Student Outcomes. In *Teaching for Excellence and Equity,* pp.7-17. Cham: Springer International Publishing.

Burton, D. and Bartlett, S. (2012). *Introduction to Education Studies*, (3rd edn.). London: Sage Publications.

Burton, D. and Bartlett, S. (2016). *Introduction to Education Studies*, (4th edn.). London: Sage Publications.

CACE (1967). *Children and their Primary Schools*, Volume 1. London: HMSO.

Campbell, P.F., Rust, A.H., Nishio, M., DePiper, J.N., Smith, T. M., Frank, T.J., Choi, Y. (2014). The relationship between teachers' mathematical content and pedagogical knowledge, teachers' perceptions, and pupil achievement. *Journal for Research in Mathematics Education*, 45(4), pp.419-459.

Cancoy, O. (2010). Mathematics teachers' topic-specific pedagogical content knowledge in the context of teaching*. Education Sciences: Theory and Practice*, 10(2), pp.749-769.

Carney, M.B., Brendefur, J. L., Thiede, K., Hughes, G. and Sutton, J. (2016). Statewide mathematics professional development: Teacher knowledge, self-efficacy, and beliefs. *Educational Policy*, 30(4), pp.539-572.

Cassel, J., and Reid, R. (1996). Use of self-regulated strategy intervention to improve word problem solving skills of student with mild disabilities. *Journal of Behavioural Education*, 6, pp.153-172.

Casanave, C.P. (2013*). Journal writing in second language education.* Ann Arbor: University of Michigan Press.

Castleberry, A., and Nolen, A. (2018). Thematic analysis of qualitative research data: Is it as easy as it sounds? *Currents in Pharmacy Teaching and Learning*, 10(6), pp.807-815.

Cavilla, D. (2017). *The effects of pupil reflection on academic performance and motivation*. *Sage Open,* 7(3), pp.1-13.

CBMS (2012). *The Mathematical Education of Teachers II*. Washington: Mathematical Association of America.

CCATS (2014). *Report on P6 National Examinations (2013). A comprehensive study of results.* Victoria: Ministry of Education.

CCATS (2015). *Report on P6 National Examinations (2014). A comprehensive study of results.* Victoria: Ministry of Education.

CCATS (2016). *Report on P6 National Examinations (2015). A comprehensive study of results.* Victoria: Ministry of Education.

CCATS (2017). *Report on P6 National Examinations (2016). A comprehensive study of results.* Victoria: Ministry of Education.

CCATS (2018). *Report on P6 National Examinations (2017). A comprehensive study of results.* Victoria: Ministry of Education.

CCATS (2019). *Report on P6 National Examinations (2018). A comprehensive study of results.* Victoria: Ministry of Education.

CCATS (2020). Report on P6 National Examinations (2019). *A comprehensive study of results*. Victoria: Ministry of Education.

Cellini, S.R., Ferreira, F. and Rothstein, J. (2010). The Value of School Facility Investments: Evidence from a Dynamic Regression Discontinuity Design. *The Quarterly Journal of Economics*, 125(1), pp.215-261.

Chakrabartty, S. N. (2013). Best split-half and maximum reliability. *IOSR Journal of Research & Method in Education*, 3(1), pp.1-8.

Chamberlin, M. (2009). Teachers' Reflections on their Mathematical Learning Experiences in a Professional Development Course. *Mathematics Teacher Education and Development*, 11, pp.22-35.

Chandler, P., Robinson, W.P., and Noyes, P. (1991). Is a proactive pupil teacher a better pupil teacher? *Research in Education*, 45(1), pp.41-52.

Chang, Y.L. (2015). Examining relationships among elementary mathematics teacher efficacy and their pupils' mathematics self-efficacy and achievement. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(6), pp.1307-1320.

Chapman, O. (2005). Constructing pedagogical knowledge of problem-solving: Preservice mathematics teachers. In H.L. Chick and J.L. Vincent (eds*.), Proceedings of the 29th PME International Conference*, 2, pp.225-232. ERIC Clearinghouse.

Chapman, O. (2017). Understanding elementary school teachers of mathematics. *Journal of Mathematics Teacher Education*. 20(3), pp.203-205.

Charalambous, C.Y. and Hill, H.C. (2012). Teacher knowledge, curriculum materials, and quality of instruction: Unpacking a complex relationship. *Journal of Curriculum Studies*, 44(4), pp.443-466.

Charalambous, C.Y., Hill, H.C. and Mitchell, R.N. (2012). Two negatives don't always make a positive: Exploring how limitations in teacher knowledge and the curriculum contribute to instructional quality. *Journal of Curriculum Studies*, 44(4), pp.489-513.

Charalambous, C., Philippou, G. and Kyriakides, L. (2008). Tracing the development of preservice teachers' efficacy beliefs in teaching mathematics during fieldwork. *Educational Studies in Mathematics,* 67(2), pp.125-142.

Charmaz, K. (2014). *Constructing Grounded Theory,* (2nd edn.). London: Sage Publications.

Chen, J.C. (2014). Teaching non-traditional adult pupils: adult learning theories in practice. *Teaching in Higher Education*, 19(4), pp.406-418.

Chen, M., Zhang, S., Tenbhomer, M. and Tate, D. (2018). Evaluation of Learning and Teaching Practice for Design-oriented Engineering Modules. In *2018 4th International Conference on Humanities and Social Science Research* (ICHSSR 2018). Atlantis Press.

Chirema, K.D. (2007). The use of reflective journals in the promotion of reflection and learning in post registration nursing pupils. *Nurse Education Today*, 27(3), pp.192-202.

Ching-shu Shen, C. (2015). Reflections on Learning How to Teach Mathematics: The Initial Training of Kindergarten Teachers. *Creative Education*, 6(12), pp.1328-1335.

Choy, S.C., Yim, J.S.C., and Tan, P.L. (2017). Reflective thinking among preservice teachers: A Malaysian perspective. *Issues in Educational Research*, 27(2), pp. 38-144,

Christensen, L. (2004). *Experimental methodology*. Boston, MA: Pearson Allyn and Bacon.

Christie, M., Carey, M., Robertson, A. and Grainger, P. (2015). Putting transformative learning theory into practice. *Australian Journal of Adult Learning*, 55 (1), pp.9-30.

Cirocki, A., and Farrell, T.S. (2017). Reflective practice for professional development of TESOL practitioners. *The European Journal of Applied Linguistics and TEFL*, 6(2), pp.5-23.

Clark M.C. and Wilson A.L. (1991). Context and rationality in Mezirow's theory of transformational learning. *In Adult Education Quarterly,* 41(2), pp.75-91.

Clarke, B. (2004). A shape is not defined by its shape. *Journal of Australian Research in Early Childhood Education,* 11(2), pp.110-122.

Clarke, D. and Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18(8), pp.947-976.

Clarà, M. (2015). What is reflection? Looking for clarity in an ambiguous notion. *Journal of Teacher Education,* 66(3), pp.261-271.

Clivaz, S. (2017). Analysing mathematics teacher learning in lesson study – a proposed theoretical framework. *The Tenth Congress of the European Society for Research in Mathematics Education (CERME 10), Dublin, Ireland*. European Society for Research Methods in Mathematics Education.

Clough, P., and Nutbrown, C. (2012). *A Student's Guide to Methodology*. London: Sage Publications.

Cobb, P., Yackel, E. and Wood, T. (1992). Interaction and learning in mathematics classroom situations. *Educational Studies in Mathematics*, 23(1), pp.99-122.

Cohen, D. (2008). Knowledge and Teaching. *Oxford Review of Education, Teacher Education, the University, and the schools. Papers for Harry Judge*, 34(3), pp.357-378.

Cohen, L., Manion, L. and Morrison, K. (2018). *Research Methods in Education,* (8th edn.). London: Routledge.

Collie, R.J., Shapka, J.D. and Perry, N.E. (2012). School climate and social–emotional learning: Predicting teacher stress, job satisfaction, and teaching efficacy. *Journal of Educational Psychology*, 104(4), pp.1189-1204.

Collin, F. (2013). Social constructivism. In B. Kaldis (eds.), *Encyclopedia of Philosophy and the Social Sciences,* 18, pp.895-898.

Collin, S., Karsenti, T. and Komis, V. (2013). Reflective practice in initial teacher training: Critiques and perspectives. *Reflective Practice*, 14(1), pp.104-117.

Collinson, V. (1999). Redefining teacher excellence. *Theory into Practice*, 38(1), pp.4-11.

Colson, T.L. and Satterfield, C. (2018). The effects of strategic compensation on teacher retention. *Power and Education*, 10(1), pp. 92-104.

Copur-Gencturk, Y. (2012). *Teachers' mathematical knowledge for teaching, instructional practices, and pupil outcomes.* Unpublished Doctoral dissertation, University of Illinois.

Cornford, I. (2002). Reflective teaching: empirical research findings and some implications for teacher education, *Journal of Vocational Education and Training*, 54(2), pp.219-236.

Cornish, L. and Jenkins, K.A. (2012). Encouraging teacher development through embedding reflective practice in assessment. *Asia-Pacific Journal of Teacher Education*, 40(2), pp.159-170.

Costigan, C.L. and Cox, M.J. (2001). Fathers' participation in family research: Is there a self-selection bias? *Journal of Family Psychology*, 15(4), pp.706-720.

Cranton, P. (2006). *Understanding and promoting transformative learning: A guide for educators of adults*. San Francisco: Jossey-Bass.

Creswell, J. and Plano Clark V. (2011). *Designing and Conducting Mixed Methods Research,* (2nd edn.). London: Sage Publications.

Creswell, J.W. and Creswell, J.D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*. International Student Edition, (5th edn.). London: Sage Publications.

Creswell, J.W. (2013). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches,* (3rd edn.). Washington DC: Sage Publications.

Cropley, B., Hanton, S., Miles, A. and Niven, A. (2010). The value of reflective practice in professional development: An applied sport psychology review. *Sport Science Review*, 19(3), pp.179-208.

Crotty, M. (1998) *The foundations of social research: Meaning and perspective in the research process.* Thousand Oaks, CA: Sage Publications.

Cueto, S., León, J., Sorto, M.A. and Miranda, A. (2017). Teachers' pedagogical content knowledge and mathematics achievement of pupils in Peru. *Educational Studies in Mathematics*, 94(3), pp.329-345.

Cummins, D.D., Kintsch, W., Reusser, K. and Weimer, R. (1988). The role of understanding in solving word problems. *Cognitive Psychology*, 20(4), pp.405-438.

Darling-Hammond, L. (2006). Assessing teacher education: The usefulness of multiple measures for assessing program outcomes. *Journal of Teacher Education*, 57(2), pp.120-138.

Darling-Hammond, L. (2013). *Getting teacher evaluation right: What really matters for effectiveness and improvement*. Oxford, OH: Teachers College Press.

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

Darcan, O.N., and Badur, B.Y. (2012). Student profiling on academic performance using cluster analysis. *Journal of e-Learning & Higher Education*. Article ID 622480, 1-8, Available online at: http://www.ibimapublishing.com/journals/JELHE/jelhe.html [Accessed 10th December 2019].

Daudelin, M.W. (1997). Learning from experience through reflection. *Organisational Dynamics*, 24(3), pp.36-48.

Davis, B. and Simmt, E. (2006). Mathematics-for-teaching: An ongoing investigation of the mathematics that teachers (need to) know. *Educational Studies in Mathematics*, 61(3), pp.293-319.

Davis, I. and Hay, S. (2018). Primary masculinities: how male teachers are regarded as employees within primary education – a global systematic literature review. *Sex Education*, 18(3), pp.280-292.

Dawson, C. (2009). *Introduction to Research Methods: A practical guide for anyone undertaking a research project*, (4th edn.). London: Robinson Publications.

Deacon, R. (2012). *The Initial Teacher Education Research Project: The initial professional development of teachers: A literature review*. Johannesburg: JET Education Services.

De Koning, B.B., Boonen, A.J., and van der Schoot, M. (2017). The consistency effect in word problem solving is effectively reduced through verbal instruction. *Contemporary Educational Psychology*, 49, pp.121-129.

Delaney, S., Ball, D.L., Hill, H.C., Schilling, S.G. and Zopf, D. (2008). Mathematical knowledge for teaching: Adapting U.S. measures for use in Ireland. *Journal of Mathematics Teacher Education,* 11(3), pp.171-197.

Delvin, M., Kift, S. and Nelson, K. (2012). Effective teaching and support of pupils from low socioeconomic status backgrounds: Practical advice for teaching staff. Resources for Australian higher education. *Australian Government Office for Learning and Teaching.*

Dempsey, M. and A. O'shea (2017). Critical evaluation and design of mathematics tasks: Pre-service teachers. *CERME 10*.

Denscombe, M. (2010). *The good research guide for small scale social research projects,* (4th edn.). Buckingham: Open University Press.

Denzin, N. and Lincoln, Y. (2018). *The SAGE Handbook of Qualitative Research*, (5th edn.). London: Sage Publications.

Depaepe, F., De Corte, E., and Verschaffel, L. (2010). Teachers' approaches towards word problem solving: Elaborating or restricting the problem context. *Teaching and Teacher Education,* 26, pp.152-160.

Depaepe, F. and König, J. (2018). General pedagogical knowledge, self-efficacy and instructional practice: Disentangling their relationship in pre-service teacher education. *Teaching and Teacher Education*, 69, pp.177-190.

Depaepe, F., Verschaffel, L., and Kelchtermans, G. (2013). Pedagogical content knowledge: A systematic review of the way in which the concept has pervaded mathematics educational research. *Teaching and Teacher Education*, 34, pp.12-25.

Dervent, F. (2015). The effect of reflective thinking on the teaching practices of preservice physical education teachers. *Issues in Educational Research*, 25(3), pp.260-275.

Deshler, J. (2015). Using modified lesson study with mathematics post-graduate teaching assistants. *Research in Mathematics Education*, 17(3), pp.242-243.

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

Desimone, L.M. (2011). A primer on effective professional development. *Phi Delta Kappa*, 92(6), pp.68-71.

Desimone, L. M., and Stuckey, D. (2014). Sustaining teacher professional development. In L. Martin, S. Kragler, D. Quatroche, & K. Bauserman (Eds.), *Handbook of professional development in education: Successful models and practices Pre-K-12*, pp.467-482. NY: Guilford.

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

Desimone, L.M. and Garet, M.S. (2015). Best practices in teacher's professional development in the United States. *Psychol. Soc. Educ*. 7, pp.252-263.

Desimone, L., Hochberg, E.D. and McMaken, J. (2016). Teacher Knowledge and Instructional Quality of Beginning Teachers: Growth and Linkages. *Teachers College Record*, 118(5), p.5.

Dewey, J. (1933). *How we think* (Revised). Boston: D.C. Heath & Co.

Ding, M. (2016). Developing pre-service elementary teachers' specialised content knowledge for teaching fundamental mathematical ideas: The case of the associative property. *International Journal of STEM Education*, 3(9), pp.1-19.

Dirkx, J.M. (2012). Self-formation and transformative learning: A response to calling transformative learning into question: some mutinous thoughts. *Adult Education Quarterly*, 62(4), pp.399-405.

Downing, S.M. (2004). Reliability: On the Reproducibility of Assessment Data. *Med Education*, 38, pp.1006-1012.

Doyle, A., Seery, N., Gumaelius, L., Canty, D., Hartell, E. (2018). Reconceptualising PCK research in DandT education: Proposing a methodological framework to investigate enacted practice. *International Journal of Technology and Design Education*. Springer. Available online at: https://doi.org/10.1007/s10798-018-9456-1 [Accessed on 10th May, 2019].

Drushlyak, M.G., Semenikhina, O.V., Proshkin, V.V., and Sapozhnykov, S.V. (2021). Training pre-service mathematics teacher to use mnemonic techniques. In *Journal of Physics: Conference Series*, 1840(1), p.012006.

Duarte, F. (2010). Addressing pupil cynicism through transformative learning. *Journal of University Teaching and Learning Practice,* 7(1), pp.1-15.

Duffy, C.E. (2006). *Transformative learning through critical reflection*: *The relationship to emotional competence.* Washington, DC: George Washington University Press.

Dunlosky, J., Rawson, K.A., Marsh, E.J., Nathan, M.J. and Willingham, D.T. (2013). Improving pupils' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, 14(1), pp.4-58.

Dunst, C.J. (2015). Improving the Design and Implementation of In-Service Professional Development in Early Childhood Intervention. *Infants and Young Children*, 28(3), pp.210-219.

Dupree, K. M. (2016). Questioning the order of operations. *Mathematics Teaching in the Middle School*, 22(3), pp.152–159.

Early, M. and Norton, B. (2015). Revisiting English as medium of instruction in rural African classrooms. *Journal of Multilingual and Multicultural Development*, 35(7), pp.674-691.

Education for All. 2015 National Review Report: the Seychelles. Available online at: http://unesdoc.unesco.org/images/0022/002299/229953e.pdf [Accessed on 9th September 2016].

Eisenberg, T. (1977). Begle revisited: Teacher knowledge and pupil achievement in algebra. *Journal for Research in Mathematics Education*, 8(3), pp.216-222.

Eisenhardt, K.M. (1989). Building theories from case study research. *Academy of Management Review*, 14(4), pp.532-550.

Ekebergh, M. (2007). Lifeworld-based reflection and learning: a contribution to the reflective practice in nursing and nursing education. *Reflective Practice*, 8(3), pp.331-343.

Elbaz, F. (1983). *Teacher thinking: A study of practical knowledge*. London: Croom Helm.

Erdem Mete, D. (2019). Learning from reflection: A case of a post-sojourn debriefing workshop with EFL university pupils. *Journal of Language and Linguistic Studies*, 15(4), pp.1376-1394.

Evens, M., Elen, J. and Depaepe, F. (2015). Developing Pedagogical Content Knowledge: Lesson Learned from Intervention Studies. *Education Research International*, Vol 2015, Article ID 790417, Available online at http://dx.doi.org/10.1155/2015/790417 [Accessed on 10th April 2016].

Ernesta, S. (2018). *Quality of learning, teaching the top priorities for the Seychelles Education Ministry*. Victoria: Ministry of Education.

Evans, L. (2008). Professionalism, professionality and the development of education professionals. *British Journal of Educational Studies*, 56(1), pp.20-38.

Even, R. (1993). Subject-matter knowledge and pedagogical content knowledge: Prospective secondary teachers and the function concept. *Journal for Research in Mathematics Education*, 24(2), pp.94-116.

Everett, G.E., Harsy, J.D., Hupp, S.D., and Jewell, J.D. (2014). An investigation of the look-ask-pick mnemonic to improve fraction skills. *Education and Treatment of Children*, pp.371-391.

Fackler, S. and Malmberg, L. (2016). Teachers’ self-efficacy in 14 OECD countries: Teacher, pupil group, school and leadership effect. *Teaching and Teacher Education*, 56, pp.185-195.

Farrell, T.S.C. (2011). Keeping Score: Reflective practice through classroom observations. *RELC Journal*, 42(3), pp.265-272.

Fauskanger, J. and Mosvold, R. (2013b). Teachers’ mathematical knowledge for teaching equality. In A. M. Lindmeier and A. Heinze (eds.), *Proceedings of the 37th Conference of the International Group for the Psychology of Mathematics Education*, 2, pp.289-296. Kiel: PME.

Fauskanger, J. and Mosvold, R. (2014). Studying teachers’ knowledge by the use of multiple-choice items: the case of “I ‘m not sure”. *Nordic Studies in Mathematics Education*, 19(4), pp.41-55.

Fennema, E. and Franke, M.L. (1992). Teachers' knowledge and its impact. In D.A. Grouws (ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics*, pp.147-164. Macmillan Publishing.

Fenwick, L., and Cooper, M. (2013). Learning about the Effects of Context on Teaching and Learning in Pre-Service Teacher Education. *Australian Journal of Teacher Education*, 38(3), pp.96-110.

Feriver, S., Teksöz, G., Refika, O. and Reid, A. (2016). Training early childhood teachers for sustainability: towards a 'learning experience of a different kind’. *Environmental Education Research*, 22(5), pp.717-746.

Ferraro, J.M. (2000). Reflective practice and professional development. *ERIC Clearinghouse on Teaching and Teacher Education.* ED449120, *ERIC Digest*, pp.1-7.

Fink. A. (2013). *How to conduct surveys: A step-by-step Guide*. London: Sage Publications.

Finlay, L. (2008). *Reflecting on reflective practice* [online]. Paper presented at the Practice-based Professional Learning Centre, The Open University, UK. Available at : http://ncsce.net/wp-content/uploads/2016/10/Finlay-2008-Reflecting-on-reflective-practice-PBPL-paper-52.pdf [Accessed on 14th October 2019].

Flick, U. (2014). *An introduction to qualitative research, (*5th edn*.)*. London: Sage Publications.

Flyvbjerg, B. (2006). Five misunderstandings about case study research. *Qualitative Inquiry*, 12(2), pp.219-245.

Flyvbjerg, B. (2011). Case Study. In N.K. Denzin and Y.S. Lincoln (eds.). *The Sage Handbook of Qualitative Research,* (4th edn.), pp.341-358. London: Sage Publications.

Fontana, J. L., Scruggs, T.E. and Mastropieri, M.A. (2007). Mnemonic strategy instruction in inclusive secondary social studies classes. *Remedial and Special Education*, 28(6), pp.345-355.

Fook, J. (2007). *Reflective practice and critical reflection*. In J. Lishman (ed.), *Handbook for practice learning in social work and social care,* (2nd edn.), pp. 440-454. London: Jessica Kingsley Publications.

Foong, L., Binti, M. and Nolan, A. (2018). Individual and collective reflection: Deepening early childhood pre-service teachers’ reflective thinking during practicum. *Australasian Journal of Early Childhood,* 43(1), pp.43-51.

Forrester, G. (2005). All in a day's work: primary teachers ‘performing’ and ‘caring’. *Gender and Education*, 17(3), pp.271-287.

Forrester, G. (2011). Performance management in education: milestone or millstone? *Management in Education*, 25(1), pp.5-9.

Forrester, G. and Garratt, D. (2016). *Education policy unravelled*, (2nd edn.). London: Bloomsbury.

Freire, P. (1996). *Pedagogy of the oppressed* (revised). *New York:* Continuum.

Fuller, R. (1997). Elementary teachers' pedagogical knowledge contents of mathematics. *Mid-western Educational Researcher*, 10(2), pp.9-16.

Fung, D., Kutnick, P., Mok, I., Leung, F., Pok-Yee Lee, B., Mai, Y.Y. and Tyler, M.T. (2017). Relationships between teachers' background, their subject knowledge and pedagogic efficacy, and pupil achievement in primary school mathematics in Hong Kong: An indicative study. *International Journal of Educational Research,* 81, pp.119-130.

Furinghetti, F. and Pehkonen, E. (2002). Rethinking characterisations of beliefs. In *Beliefs: A hidden variable in mathematics education?* pp.39-57. Dordrecht: pringer,

Freeman-Green, S.M., O'Brien, C., Wood, C.L., and Hitt, S.B. (2015). Effects of the SOLVE strategy on the mathematical problem-solving skills of secondary students with learning disabilities. *Learning Disabilities Research & Practice*, 30(2), pp.76-90.

Gagnon, J.C., and Maccini, P. (2001). Preparing students with disabilities for algebra. *Teaching Exceptional Children*, 34(1), pp.8-15.

Gamlem, S. (2015). Feedback to support learning: changes in teachers' practice and beliefs. *Teacher Development*, 19(4), pp.461-482.

Garet, M. S., Wayne, A.J., Stancavage, F., Taylor, J., Eaton, M., Walters, K., Doolittle, F. (2011). Middle school mathematics professional development impact study: Findings after the second year of implementation. Washington, DC: U.S. Department of Education. Available online at: https://files.eric.ed.gov/fulltext/ED519922.pdf [Accessed on 5th September 2018].

Geiger, V., Anderson, J. and Hurrell, D. (2017). A case study of effective practice in mathematics teaching and learning informed by Valsiner's zone theory. *Mathematics. Education Research Journal*, 29(2), pp.143-161.

Gersten, R., Dimino, J., Jayanthi, M., Newman-Gonchar, R. and Taylor, M.J. (2013). Impact of the Teacher Study Group Professional Development Program on Student Vocabulary and Observed Teaching Practice: A Replication in First Grade Classrooms, 2013 Conference. *Society for Research on Educational Effectiveness*, pp.1-7. SREE Spring

Gibbs, G. (1988). *Learning by Doing: A guide to teaching and learning methods. Further Education Unit*. Oxford: Oxford Polytechnic.

Glaser, B.G., and Strauss, A.L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine.

Golding, J. (2017). Mathematics teacher capacity for change. *Oxford Review of Education* 43(4), pp.502-517.

Goldsmith, L.T., Doerr, H.M. and Lewis, C.C. (2014). Mathematics teachers' learning: A conceptual framework and synthesis of research. *Journal of Mathematics Teacher Education*, 17(1), pp.5-36.

González, G. and Deal, J.T. (2019). Using a creativity framework to promote teacher learning in lesson study. *Thinking Skills and Creativity*, (32), pp.114-128.

Goos, M. and Geiger, V. (2010). Theoretical perspectives on mathematics teacher change. *Journal of Mathematics Teacher Education*, 13(6), pp.499-507.

Goos, M., Smith, T. and Thornton, S. (2008). *Research on the pre-service education of teachers of mathematics*. In H. Forgasz, A. Barkatsas, A. Bishop, B. Clarke, S. Keast, W. T. Seah and P. Sullivan (eds.), *Research in Mathematics Education in Australasia*, pp.291-311. Monash University, Australia: Sense Publishers.

Govindasamy, K. and Velmurugan, T. (2018). Analysis of pupil academic performance using clustering techniques. *International Journal of Pure and Applied Mathematics*, 119(15), pp.309-323.

Graves, S. (2011) Performance or enactment? The role of the higher level teaching assistant in a remodelled school workforce in England. *Management in Education*, 25(1), pp.15–20.

Graham, L.J., White, S.L., Cologon, K., and Pianta, R.C. (2020). Do teachers' years of experience make a difference in the quality of teaching? *Teaching and Teacher Education*, 96, pp.1-10.

Green, J., Roberts, H., Petticrew, M., Steinbach, R., Goodman, A., Jones, A. and Edwards, P. (2015). Integrating quasi-experimental and inductive designs in evaluation: a case study of the impact of free bus travel on public health. *Evaluation*, 21(4), pp.391-406.

Greenall, J. and Sen, B. (2014). Reflective practice in the library and information sector. *Journal of Librarianship and Information Science,* 48(2), pp.1-29.

Gresham, G. (2007). A Study of Mathematics Anxiety in Pre-Service Teachers. *Early Childhood Education Journal*, 35(2), pp.181-188.

Griffin, C.C., Jitendra, A.K. and League, M.B. (2009). Inexperienced special educators' instructional practices, communication patterns, and content knowledge for teaching mathematics. *Teacher Education and Special Education*, 32(4), pp.319-336.

Grossman, P.L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York, NY: Teachers College Press.

Guillaume, A.M., and Kirtman, L. (2010). Mathematics stories: preservice teachers' images and experiences as learners of mathematics. *Issues in Teacher Education*, 19(1), pp.121-143.

Günbas, N. (2020). Students Solve Mathematics Word Problems in Animated Cartoons. *Malaysian Online Journal of Educational Technology*, 8(2), pp.43-57.

Gunbas, N. (2015). Students' mathematics word problem-solving achievement in a computer-based story. *Journal of Computer Assisted Learning*, 31(1), pp.78-95.

Guskey, T.R. (2002). Professional development and teacher change. *Teachers and Teaching*, 8(3), pp.381-391.

Guskey, T.R. and Sparks, D. (1996). Exploring the relationship between staff development and improvements in pupil learning, *Journal of Staff Development*, 17(4), pp.34-38.

Habermas, J. (1971). *Knowledge and human interests*. Boston: Beacon Press.

Hamilton, L and Corbett-Whittier, C. (2013). *Using Case Study in Education Research*. BERA Research Methods. London: Sage Publications.

Hammersley, M. (2017). Research ethics. In R. Coe, M. Waring, L. Hedges and J. Arthur, (eds.), *Research Methods and Methodologies in Education*, (2nd edn.), pp.58-59. London: Sage Publications.

Hammersley, M. (2010). Can we re-use qualitative data via secondary analysis? Notes on some terminological and substantive issues. *Sociological Research Online*, 15(1), pp.47-53.

Hammond-Stoughton, E. (2007). How will I get them to behave? Pre-service teachers reflect on classroom management. *Teaching and Teacher Education*, 23(7), pp.1024-1037.

Handley, M. A., Lyles, C.R., McCulloch, C. and Cattamanchi, A. (2018). Selecting and improving quasi-experimental designs in effectiveness and implementation research. *Annual Review of Public Health,* 39, pp.5-25.

Handscomb ,G. and Cockburn, A.D. (2013). *Teaching Children 3-11: a pupil's guide*, (3rd edn.). London: Sage Publications.

Hanson, M. (2001). Institutional theory and educational change. *Educational Administration Quarterly*, 37(5), pp.637-661.

Hanuscin, D.L. (2013). Critical incidents in the development of pedagogical content knowledge for teaching the nature of science: A prospective elementary teacher's journey. *Journal of Science Teacher Education,* 24(6), pp.933-956.

Hanushek (2008). Education Product Functions. *Palgrave Encyclopedia.* Hoover Institution, Stanford University, 2, pp.1-9.

Hanushek (2016). What matters for pupil achievement: updating Coleman on the influence of families and schools. *Education Next*, 16(2), pp.18-26.

Hanushek, E.A., Piopiunik, M., and Wiederhold, S. (2019). The value of smarter teachers international evidence on teacher cognitive skills and student performance. *Journal of Human Resources*, 54(4), pp.857-899.

Harnett, J. (2012). Reducing discrepancies between teachers' espoused theories and theories-in-use: An action research model of reflective professional development. *Educational Action Research,* 20(3), pp.367-384.

Harrison, J. (2012). Professional learning and reflective practitioner. In S. Dymoke, (ed) *Reflective Teaching and Learning in the Secondary School,* pp.6-41. London: Sage Publications.

Harootunian. B. and Yargar, G.P. (1980) *Teachers' conceptions of their own success*. Paper presented at the Annual Meeting of the American Educational Research Association, Boston, MA.

Hart, M. (1990). Critical theory and beyond: Further perspectives on emancipatory education. *Adult Education Quarterly*, 40(3), pp.125-138.

Harvey, M., Coulson, D. and McMaugh, A. (2016). Towards a theory of the ecology of reflection: Reflective practice for the experiential learning in higher education. *Journal of University Teaching and Learning Practice*, 13(2), pp.1-20.

Hatisaru, V. and Erbas, A.K. (2017). Mathematical knowledge for teaching the function concept and pupil learning outcomes. *International Journal of Science and Mathematics Education*, 15(4), pp.703-722.

Hattie, J. (2003). Teachers make a difference. What is the research evidence? *International Journal of Educational Research*, 37, pp.449-481.

Hattie, J. (2009). *Visible learning: a synthesis of over 800 meta-analyses relating to achievement*. London: Routledge.

Hattie, J. (2012). *Visible learning for teachers: Maximising impact on learning*. New York: Routledge.

Heater, M.; Howard, L. and Linz, E. (2012). Solving word problems: As easy as PIES! *Journal of Science Education for Students with Disabilities*, 16(1), pp.15-22.

Hennink, M., Hutter, I. and Bailey, A. (2011). *Qualitative research methods.* London: Sage Publications.

Herbert, S. and Rainford, M. (2014). Developing a model for continuous professional development by action research. *Professional Development in Education*, 40(2), pp.243-264.

Hertzog, H. and O'Rode, N. (2011). Improving the Quality of Elementary Mathematics Student Teaching: Using Field Support Materials to Develop Reflective Practice in Student Teachers. *Teacher Education Quarterly,* 38(3), pp.89-111.

Hickendorff, M. (2013). The language factor in elementary mathematics assessments: Computational skills and applied problem solving in a multidimensional IRT framework. *Applied Measurement in Education*, 26(4), pp.253-278

Hiebert, J., Stigler, J., Jacobs, J., Givvin, K., Garnier, H., Smith, M., Hollingsworth, H., Manaster, A., Wearne, D. and Gallimore, R. (2005). Mathematics teaching in the United States today (and tomorrow): results from the TIMSS 1999 video study. *Educational Evaluation and Policy Analysis*, 27(2), pp.111-132.

Hightower, A.M., Delgado, R.C., Lloyd, S.C., Wittenstein, R., Sellers, K. and Swanson, C. B. (2011). Improving pupil learning by supporting quality teaching: Key issues, effective strategies. *Editorial Projects in Education*. *Agency for UNESCO*. Available online at: http://www.edweek.org/media/eperc_qualityteaching_12.11.pdf [Accessed on 21st September 2016].

Higgins, S., Kokotsaki, D. and Coe, R. (2011). Toolkit of Strategies to Improve Learning. Summary for Schools Spending the Pupil Premium. London: CEM Centre.

Hill, H.C. and Ball, D.L. (2004). Learning mathematics for teaching: Results from California’s mathematics professional development institutes. *Journal for Research in Mathematics Education*, 35(5), pp.330-351.

Hill, H.C. and Charalambos Y. (2012). Teacher knowledge, curriculum materials, and quality of instruction: Lessons learned and open issues. *Journal of Curriculum Studies*, 44(4), pp.559-576.

Hill, H.C., Beisiegel, M., and Jacob, R. (2013). Professional Development Research Consensus, Crossroads, and Challenges. *Educational Researcher*, 42(9), pp.476-487.

Hill, H.C., Rowan, B. and Ball, D.L. (2005). Effects of teachers' mathematical knowledge for teaching on pupil achievement. *American Educational Research Journal*, 42(2), pp.371-406.

Hill, H., Schilling, S. and Ball, D. (2004). Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal*, 105(1), pp.11-30.

Hill, H.C. (2010). The nature and predictors of elementary teachers’ mathematical knowledge for teaching. *Journal for Research in Mathematics Education*, 41(5), pp.513-545.

Hill, H.C., Ball, D.L. and Schilling, S.G. (2008). Unpacking pedagogical content knowledge: Conceptualising and measuring teachers’ topic specific knowledge of pupils. *Journal for Research in Mathematics Education,* 39(4), pp.372-400.

Hill, H.C., Rowan, B. and Ball, D.L. (2005). Effects of teachers’ mathematical knowledge for teaching on pupil achievement. *American Educational Research Journal*, *42*(2), pp.371-406.

Hertzog, H.S. and O'Rode, N. (2011). Improving the quality of elementary mathematics pupil teaching: Using field support materials to develop reflective practice in pupil teachers. *Teacher Education Quarterly*, 38(3), pp.89-111.

Hoggan, C. (2016). Transformative learning as a metatheory: Definition, criteria, and typology. *Adult Education Quarterly*, 66, pp.57-75.

Hoggan, C., Mälkki, K., Finnegan, F. (2017). Developing the theory of perspective transformation: Continuity, intersubjectivity, and emancipatory praxis. *Adult Education Quarterly*, 67(1), pp.48-64.

Holmes, V. (2012). Depth of teachers' knowledge: Frameworks for teachers' knowledge of mathematics. *Journal of STEM Education Innovations and Research*, 13(1), p.55.

Hong, H.Y., and Chai, C.S. (2017). Principle-based design: Development of adaptive mathematics teaching practices and beliefs in a knowledge building environment. *Computers and Education,* 115, pp.38-55.

Hoover, M., Mosvold, R., Ball, D.L. and Lai, Y. (2016). Making progress on mathematical knowledge for teaching. *The Mathematics Enthusiast*, 13(2), pp.3-34.

Hopfenbeck, N. (2018). Assessors for learning: Understanding teachers in contexts. *Assessment in Education*. *Principles, Policy and Practice*, 25 (5), pp.439-441.

Hott, B.L., Isbell, L. and Oettinger, T. (2014). *Strategies and interventions to support pupils with mathematics disabilities*. Overland Park, KS: Council for Learning Disabilities.

Hourigan, M. and Leavy, A.M. (2017). Rate your course! Student teachers' perceptions of a primary pre-service mathematics education programme. *Journal of Curriculum Studies*, 49(6), pp.802-829.

Hourigan, M. and O'Donoghue, J. (2015). Addressing prospective elementary teachers' mathematics subject matter knowledge through action research. *International Journal of Mathematical Education in Science and Technology*, 46(1), pp.56-75.

Hsieh, F.J. (2013). Strengthening the conceptualisation of mathematics pedagogical content knowledge for international studies: A Taiwanese perspective. *International Journal of Science and Mathematics Education*, 11(4), pp.923-947.

Hurrell, D.P. (2013). What Teachers Need to Know to Teach Mathematics: An argument for a reconceptualised model. *Australian Journal of Teacher Education*, 38(11), pp.54-64.

Impedovo, M.A. and Khatoon Malik, S. (2016). Becoming a Reflective In-service Teacher: Role of Research Attitude. *Australian Journal of Teacher Education,* 41(1), pp.100-112.

Ingvarson, L., Meiers, M. and Beavis, A. (2005). Factors affecting the impact of professional development programs on teachers' knowledge, practice, pupil outcomes and efficacy. *Education Policy Analysis Archives*, 13(10), pp.1-26.

International Mathematical Union. (2009). *Mathematics in Africa: Challenges and Opportunities*. Available online at: http://www.mathunion.org/.../Mathematics_in_Africa_Challenges_Opportunities.pdf [Accessed on 11th August 2015].

Ishola, A.A. and Udofia I.G.R. (2017). Effect of Demographic Factors and Teachers' Mastery of Instructional Designs as Predictors of Pupils achievement in Mathematics. *Journal of Educational Research and Development,* 15(1), pp.10-24.

Isikoglu, N., Basturk, R. and Karaca, F. (2009). Assessing in-service teachers' instructional beliefs about pupil-centered education: A Turkish perspective. *Teaching and Teacher Education*, 25(2), pp. 350-356.

Isiksal, M., and Cakiroglu, E. (2008). Pre-service teachers' knowledge of pupils' cognitive processes about the division of fractions. *Hacettepe University Journal of Education*, 35(35), pp.175-185.

Israel, M. (2015). *Research Ethics and Integrity for Social Scientists*. (2nd edn). UK: CPI Group.

Jackson, L. (2015). Challenges to the global concept of pupil-centered learning with special reference to the United Arab Emirates: ‘Never fail a Nahayan’. *Educational Philosophy and Theory*, 47(8), pp.760-773.

Jacob, A. and McGovern, K. (2015). The mirage: Confronting the hard truth about our quest for teacher development. *TNTP*. Available online at: http://tntp.org/assets/documents /TNTP-Mirage_2015.pdf [Accessed on 16th March 2019].

Jacob, R., Hill, H. and Corey, D. (2017). The Impact of a Professional Development Program on Teachers' Mathematical Knowledge for Teaching, Instruction, and Student Achievement. *Journal of Research on Educational Effectiveness*, 10(2), pp.379-407.

Jakobsen, A. (2014). Developing an understanding of horizon content knowledge: Experiences from a practice-based approach in Norway. pp.1-6. Available online at: https://directorymathsed.net/montenegro/Jakobsen.pdf [Accessed on 13th May 2018].

Jakobsen, A. and Masvold, R. (2015). Mathematical knowledge for teaching – A Review of Empirical Research. In D. Huillet (ed.), *Proceedings of the 23rd Southern African Association for Research in Mathematics, Science and Technology Education*, pp.115-124.

Jakobsen, A., Thames, M.H. and Ribeiro, C.M. (2013). *Delineating issues related to horizon content knowledge for mathematics teaching.* Paper presented at the Eighth Congress of European Research in Mathematics Education (CERME-8). Available online at: http://cerme8.metu.edu.tr/wgpapers/WG17/WG17_Jakobsen_Thames_Ribeiro.pdf [Accessed on 20th May 2015].

Jakobsen, A., Thames, M.H., Ribeiro, M. and Delaney, S. (2012). Using practice to define and distinguish horizon content knowledge. *Paper presented at the 12th International Conference on Mathematical Education,* Seoul, Korea, pp.4635-4644.

James Report (1972). *Teacher Education and Training*. London: HMSO.

Javadi, M. and Zarea, M. (2016). Understanding Thematic Analysis and its Pitfalls. *Journal of Client Care,* 1(1), pp.33-39.

Jeon, H. (2018). Teacher efficacy research in a global context. In M. Akiba, and G. LeTendre (eds.), *International Handbook of Teacher Quality and Policy,* pp. 414-429. New York, NY: Taylor and Francis.

Jitendra, A.K., Peterson-Brown, S., Lein, A.E., Zaslofsky, A.F., Kunkel, A.K., Jung, P.G. and Egan, A.M. (2015). Teaching mathematical word problem-solving: The quality of evidence for strategy instruction priming the problem structure. *Journal of Learning*, 48(1), pp.51-72.

Johnson, C.C. and Fargo, J.D. (2014). A study of the impact of transformative professional development on Hispanic pupil performance on state mandated assessments of science in elementary school. *Journal of Elementary Science Teacher Education*, 25(7), pp. 845-859.

Johnson, K.E. and Golombek, P. (2002). *Teachers’ narrative inquiry as professional development*. New York: Cambridge University Press.

Johnson, R.B. and Onwuegbuzie, A.J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), pp.14-26.

Jonassen, D.H. (2003) Designing research-based instruction for story problems. *Educational Psychology Review*, 15, pp.267–296.

Jones, M. (2009). Transformational Learners, Transformational Teachers. *Australian Journal of Teacher Education*, 34(2), pp.15-27.

Jones, S., Schipper, Y., Ruto, S. and Rajani, R. (2014). Can your child read and count? measuring learning outcomes in east Africa. *Journal of African Economies*, 23(5), pp.643-672.

Joyner, R., Rouse, W., Glatthorn, A. (2013). *Writing the winning thesis or dissertation*. A step-by- step Guide, (3rd edn.). London: Sage Publications.

Jukes, M.C., Turner, E. L., Dubeck, M.M., Halliday, K.E., Inyega, H.N., Wolf, S. and Brooker, S.J. (2017). Improving literacy instruction in Kenya through teacher professional development and text messages support: A cluster randomised trial. *Journal of Research on Educational Effectiveness*, 10(3), pp. 449-481.

Julaihi, N.H., Li, V.L. and Eng, T.H. (2020). Teachers' Efficacy Beliefs in Mathematics Teaching: A Study of Public Primary Schools in Sarawak. *International Journal of Service Management and Sustainability*, 5(1), pp.63-82.

Jung, E., Brown, E. and Karp. K. (2014). Role of teacher characteristics and school resources in early mathematics learning*. Learning Environ Res*, 17(2), pp.209-228.

Jurowski, K, Krzeczkowska M, Własiuk P, Jurowska, A. (2016). Comprehensive review of mnemonic devices and their applications: *State of the art. IeJSME* 9(3), pp.4-9.

Kahn, W.A. (1990). Psychological conditions of personal engagement and disengagement at work. *Academy of Management Journal*, 33(4), pp.692-724.

Kalder, R.S. (2012). Are we contributing to our students' mistakes? *The Mathematics Teacher*, 106(2), pp.90–91.

Kang, H.S., Cha, J. and Ha, B.W. (2013). What should we consider in teachers' professional development impact studies? Based on the conceptual framework of Desimone. *Creative Education*, 4(4), pp.11-18.

Kapsalis, G., Ferrari, A., Punie, Y, Conrads, J., Collado, A., Hotulainen, R., Rämä, I., Nyman, L., Oinas, S. and Ilsley, P. (2019). Evidence of innovative assessment: Literature review and case studies, EUR 29882. Available online at: doi:10.2760/552774. [Accessed on 30th December 2019].

Kara, H. (2015). *Creative research methods in the social sciences: A practical guide*. Bristol: Policy Press.

Karsenty, R. (2018*).* Professional development of mathematics teachers: Through the lens of the camera. In *Invited lectures from the 13th international Congress on Mathematical Education,* pp. 269-288.Cham: Springer.

Kast, J., Lindner, K.T., Gutschik, A., and Schwab, S. (2021). Austrian teachers' attitudes and self-efficacy beliefs regarding at-risk students during home learning due to COVID-19. *European Journal of Special Needs Education*, 36(1), pp.14-126.

Kaya, S., Kablan, Z., Akaydin, B.B., and Demir, D. (2015). Teachers' awareness and perceived effectiveness of instructional activities in relation to the allocation of time in the classroom. *Science Education International*, 26(3), pp.344-257.

Kelcey, B., Hill, H.C., and Chin, M.J. (2019). Teacher mathematical knowledge, instructional quality, and pupil outcomes: a multilevel quantile mediation analysis. *School Effectiveness and School Improvement*, 30(4), pp.398-431.

Kelle, U. (1997). Theory building in qualitative research and computer programs for the management of textual data. *Sociological research online*, 2(2), pp.10-22.

Keller, M.M., Neumann, K., and Fischer, H.E. (2017). The impact of physics teachers' pedagogical content knowledge and motivation on pupils' achievement and interest. *Journal of Research in Science Teaching*, 54(5), pp.586-614.

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

Kennedy, M.M., Ahn, S., and Choi, J. (2008). The value added by teacher education. In M. Cochran-Smith, S. Feiman-Nemser, D.J. McIntyre, and K.E. Demers (eds.), *Handbook of research on teacher education,* (3rd edn.), pp.1249-1273.

Kersting, N.B., Givvin, K.B., Sotelo, F.L., and Stigler J.W. (2010). Teachers' analyses of classroom video predict pupil learning of mathematics: Further explorations of a novel measure of teacher knowledge. *Journal of Teacher Education*, 61, pp.172-181.

Kersting, N.B., Givvin, K.B., Thompson, B.J., Santagata, R., and Stigler, J.W. (2012). Measuring usable knowledge teachers' analyses of mathematics classroom videos predict teaching quality and pupil learning. *American Educational Research Journal*, 49(3), pp.568–589.

Khalaf, B.K., and Zin, Z.B.M. (2018). Traditional and Inquiry-Based Learning Pedagogy: A Systematic Critical Review. *International Journal of Instruction*, 11(4), pp.545-564.

Khan, S. (2012). The relationship between teachers' self-efficacy and pupils' academic achievement at secondary level. *Language in India*, 12(10), pp.436-449.

Khanjani, A, Vahdany. F, and Jafarigohar, M. (2018). Effects of Journal Writing on EFL Teacher Trainees' Reflective Practice. *Research in English Language Pedagogy*. Relp. 6(1), pp.56-77.

Killion, J.P., and Todnem, G.R. (1991). A process for personal theory building. *Educational Leadership,* 48(6), pp.14-16.

Kim, Y. (2010). The pilot study in qualitative inquiry: Identifying issues and learning lessons for culturally competent research. *Qualitative Social Work*, 10(2), pp.190-206.

Kim, Y. (2013). *Teaching mathematical knowledge for teaching: Curriculum and challenges*. (Unpublished doctoral dissertation). University of Michigan.

Kinach, B. (2002). Understanding and learning-to-explain by representing mathematics: Epistemological dilemmas facing teacher educators in the secondary mathematics "methods" course. *Journal of Mathematics Teacher Education*, 5(2), pp.153-186.

Kind, V. (2009). Pedagogical content knowledge in science education: perspectives and potential for progress. *Studies in Science Education*, 45(2), pp.169-204.

King, D., Horrocks, C. and Brooks, J. (2019). *Interviews in Qualitative Research, (*2nd edn.). London: Sage Publications.

King, F. (2014). Evaluating the Impact of Teacher Professional Development: An Evidence Based Framework. *Professional Development in Education*, 40(1), pp.89-111.

Kinsella, E.A. (2009). Professional knowledge and the epistemology of reflective Practice. *Nursing Philosoph*y, 11(1), pp.3-14.

Kiran, B. (2014). Testing the impact of educational expenditures on economic growth: new evidence from Latin American countries. *Quality and Quantity*, 48(3), pp.1181-1190.

Kisirkoi, F.K., and Kadenyi, M.A. (2012). Towards Enhanced Teacher Quality in Kenya for the 21st Century Learner. *International Journal of Current Research*, 4(5), pp.216-221.

Kitsantas, A. and Baylor, A. (2001). The impact of the instructional planning self-reflective tool on preservice teacher performance, disposition, and self-efficacy beliefs regarding systematic instructional planning. *Educational Technology Research and Development*, 49(4), pp.97-106.

Klassen, R.M., and Tze, V.M.C. (2014). Teachers' self-efficacy, personality, and teaching effectiveness: A meta-analysis. *Educational Research Review*, 12, pp.59-76.

Kleickmann, T., Richter, D., Kunter, M., Elsner, J., Besser, M., Krauss, S., and Baumert, J. (2013). Teachers' content knowledge and pedagogical content knowledge: The role of structural differences in teacher education. *Journal of Teacher Education*, 64(1), pp.90-106.

Knight, J. (2008). The internationalisation of higher education: Complexities and realities. In D. Teferra and J. Knight (eds.) *Higher education in Africa: The international dimension*, pp.1-43*.* Boston: CIHE.

Knowles, M.S. (1984). *Introduction: The Arts And Science Of Helping Adults Learn. Andragogy in Action: Applying Modern Principles of Adult Learning*. San Francisco: Jossey Bass.

Knowles, M.S., Holton III, E.F., and Swanson, R.A. (2014). *The adult learner: The definitive classic in adult education and human resource development,* (8th edn.). New York, NY: Routledge.

Koellner, K., Jacobs, J., Borko, H., Schneider, C., Pittman, M.E., Eiteljorg, E., Bunning K., and Frykholm, J. (2007). The Problem-Solving Cycle: A model to support the development of teachers' professional knowledge. *Mathematical Thinking and Learning*, 9(3), pp.271-300.

Kolb, A. and Kolb, D. (2005). Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education. *Academy of Management Learning and Education*, 4(2), pp.193-212.

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.

Komba, S. and Bosco, S. (2015). Do pupils' backgrounds in the language of instruction influence secondary school academic performance? *Journal of Education and Practice*, 6(30), pp.148-156.

Korthagen, F. (1985). Reflective teaching and preservice teacher education in the Netherlands. *Journal of Teacher Education*, 36 (5), pp.11-15.

Korthagen, F.A.J. (2010). How teacher education can make a difference. Journal of Education for Teaching. *International Research and Pedagogy*, 36(4), pp.407-423.

Korthagen, F.A. and Vasalos, A. (2010). Going to the core: Deepening reflection by connecting the person to the profession. In N. Lyons (Ed.), *Handbook of Reflection and Reflective Inquiry*, pp. 529–552. New York, NY: Springer.

Korthagen, F. (2001*). Linking Practice and Theory. The Pedagogy of Realistic Teacher Education*. Mahwah: Lawrence Erlbaum Associates, Inc.

Korthagen, F.A. (2004). In search of the essence of a good teacher: towards a more holistic approach in teacher education. *Teaching and Teacher Education*, 20(1), pp.77-97.

Kouton, J. (2018). Education expenditure and economic growth: Some empirical evidence from Côte d'Ivoire. *MPRA Paper* No. 88350, pp. 22-34. Available online at: https://mpra.ub.uni-muenchen.de/88350/ [Accessed on 16th March 2019].

Krainer, K., Hsieh, F.J., Peck, R., and Tatto, M.T. (2015). The TEDS-M: Important Issues, Results and Questions. In S.J. Cho (Ed.), *The Proceedings of the 12th International Congress on Mathematical Education,* pp.99-121. Cham: Springer.

Kramer, M. (2018). Promoting teachers' agency: Reflective practice as transformative disposition. *Reflective Practice*, 19(2), pp.211-224.

Krauss, S., Baumert, J. and Blum, W. (2008). Secondary mathematics teachers' pedagogical content knowledge and content knowledge: Validation of the COACTIV constructs. *The International Journal on Mathematics Education*, 40(5), pp. 873-892.

Krawec, J., Huang, J., Montague, M., Kressler, B., and de Alba, A.M. (2013). The effects of cognitive strategy instruction on knowledge of math problem-solving processes of middle school pupils with learning disabilities. *Learning Disability Quarterly*, 36(2), pp.80-92.

Kreitner , R. , and Kinicki, A.(2007) *Organizational behaviour*. Whitby, Ontario: McGraw-Hill.

Krpan, K.M. (2018). *Teaching math with meaning: Cultivating efficacy through learning competencies, grades K-8*. North York, ON: Pearson.

Kuennen, E.W., and Beam, J.E. (2020). Teaching the mathematics that teachers need to know: Classroom ideas for supporting prospective elementary teachers' development of mathematical knowledge for teaching. *The Mathematics Enthusiast*, 17(2), pp.771-805.

Kultsum, U. (2017). *The Concept of Pedagogical Content Knowledge (PCK): Recognizing the English Teachers' Competences in Indonesia*. In 2nd International Conference on Innovative Research Across Disciplines (ICIRAD 2017). Atlantis Press.

Kumi-Yeboah, A., and James, W. (2012). Transformational teaching experience of a novice teacher: A narrative of an award-winning teacher. *Adult Learning*, 23(4), pp.170-177.

Kundin, D.M. (2010). A conceptual framework for how evaluators make everyday Practice decisions. *American Journal of Evaluation,* 31(3), pp.347-362.

Künsting, J., Neuber, V., and Lipowsky, F. (2016). Teacher self-efficacy as a long-term predictor of instructional quality in the classroom. *European Journal of Psychology of Education - EJPE Springer Science and Business Media B.V.,* 31(3), pp.299-322.

Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., and Hachfeld, A. (2013). Professional competence of teachers: Effects on instructional quality and pupil development. *Journal of Educational Psychology*, 105(3), pp.805-820.

Kupari, P. (2003). Instructional practices and teachers' beliefs in Finnish mathematics education. *Studies in Educational Evaluation*, 29(3), pp.243-257.

Kurshumlia, R., and Vula, E. (2013). Mathematics word problem-solving for third grade pupils. *Albania International Conference on Education*, pp.389-401.

Kutaka, T.S., Ren, L., Smith, W.M., Beattie, H.L., Edwards, C.P., Green, J.L. and Lewis, W. J. (2018). Examining change in K-3 teachers' mathematical knowledge, attitudes, and beliefs: the case of Primarily Maths. *Journal of Mathematics Teacher Education*, 21(2), pp.147-177.

Kutaka, T.S., Smith, W. M., Albano, A.D., Pope-Edwards, C., Ren, L., Beattie, H.L., Lewis, W.J., Heaton, R.M. (2017). Connecting teacher professional development and pupil achievement: A 4-year study of an elementary Mathematics specialist program. *Journal of Teacher Education*, 68(2), pp.140-154.

Kwon, N.Y. and Orrill C.H. (2007). Understanding a Teacher's Reflections: A Case Study of a Middle School. *School Science and Mathematics*, 107(6), pp.246-57.

Kyophilavong, P., Ogawa, K., Kim, B. and Nouansavanh, K. (2018). Does Education Promote Economic Growth in Lao PDR? Evidence from Cointegration and Granger Causality Approaches. *The Journal of Developing Areas*, 52(2), pp.1-11.

Lai, M.Y., and Clark, J. (2018). Extending the notion of Specialized Content Knowledge: Proposing constructs for SCK. *Mathematics Teacher Education and Development*, 20(2), pp.75-95.

Lai, G. and Calandra, B. (2010). Examining the Effects of Computer-Based Scaffolds on Novice Teachers' Reflective Journal Writing. *Educational Technology Research and Development,* 58(8), pp.421-437.

Lannin, J.K., Webb, M., Chval, K., Arbaugh, F., Hicks, S., Taylor, C. and Bruton, R. (2013). The development of beginning mathematics teacher pedagogical content knowledge. *Journal of Mathematics Teacher Education*, 16(6), pp.403-426.

Lavrijsen, J. and Nicaise, I. (2016). Educational tracking, inequality and performance: New evidence from a differences-in-differences technique. *Research in Comparative and International Education*, 11(3), pp.334-349.

Leask and Liversidge (2013). *Learning to teach mathematics in the secondary school. A companion to school experience*. Ashford Colour Press (UK): Rouledge Publishing.

Leavy, A. and Hourigan, M. (2016). Using lesson study to support knowledge development in initial teacher education: Insights from early number classrooms. *Teaching and Teacher Education,* 57, pp.161-175.

Leavy, A. and Hourigan, M. (2018a). Using Lesson Study to Support the Teaching of Early Number Concepts: Examining the Development of Prospective Teachers' Specialised Content Knowledge. *Early Childhood Education Journal*, 46(1), pp.47-60.

Leavy, A. and Hourigan, M. (2018b). The beliefs of 'Tomorrow's Teachers' about mathematics: precipitating change in beliefs as a result of participation in an Initial Teacher Education Programme. *International Journal of Mathematical Education in Science and Technology*, 49(5), pp.759-777.

Lebak, K. and Tinsley, R. (2010). Can inquiry and reflection be contagious? Science teachers, pupils, and action research. *Journal of Science Teacher Education*, 21(8), pp.953-970.

Lechner, M. (2011). The estimation of causal effects by difference-in-difference methods. *Foundations and Trends® in Econometrics*, 4, pp.165-224.

Lee, H.J. (2005). Understanding and assessing preservice teachers' reflective thinking. *Teaching and Teacher Education*, 21(6), pp.699-715.

Lee, Y., Capraro, R.M. and Capraro M.M. (2018). Mathematics teachers' subject matter knowledge and pedagogical content knowledge in problem posing. *International Electronic Journal of Mathematics Education*, 13(2), pp.75-90.

Leech, N.L. and Onwuegbuzie, A.J. (2007). An array of qualitative analysis tools: A call for data analysis triangulation. *School Psychology Quarterly*, 22(4), pp.557-584.

Leeferink, H., Koopman, M., Beijaard, D. and Schellings, G.L.M. (2019). Overarching professional identity themes in pupil teacher workplace learning. *Teachers and Teaching*, 25(1), pp.69-89.

Leigh, J., and Bailey, R. (2013). Reflection, Reflective Practice and embodied Reflective Practice. *Body*. *Movement and Dance in Psychotherapy*, 8(3), pp.160-171.

Leitch, C.; Hill, F. and Harrison, R. (2010). The philosophy and practice of interpretivist research in entrepreneurship: Quality, validation, and trust. *Organisational Research Methods*, 13(1), pp.67-84.

Leong Y.H., and Janjaruporn R. (2015). Teaching of Problem Solving in School Mathematics Classrooms. In Cho S. (eds.) *The Proceedings of the 12th International Congress on Mathematical Education*. Cham: Springer.

Leste, A., Valentin, J. and Hoareau, F. (2005). The SACMEQ II Project in the Seychelles: A Study of the Conditions of Schooling and the Quality of Education. *SACMEQ Educational Policy Research Series.* Victoria, Zimbabwe: Ministry of Education and Youth Harare.

Lester, et al. (1994). Learning how to teach via problem solving. NCTM: *Professional Development for Teachers of Mathematics*, pp.152-166.

Lewis, C., Perry, R., and Murata, A. (2006). How should research contribute to instructional improvement? The case of lesson study. *Educational Researcher*, *35*(3), pp.3-14.

Lewis, A.B., and Mayer, R.E. (1987). Students' miscomprehension of relational statements in arithmetic word problems. *Journal of Educational Psychology*, 79, pp.363-371.

Levin, J.R. (1993). Mnemonic strategies and classroom learning: A twenty-year report card. *The Elementary School Journal*, 94(2), pp.235-244.

Lichtman, M. (2011). *Understanding and evaluating qualitative educational research*. London: Sage Publications.

Lichtman, M. (2013). *Qualitative Research in Education*: A user's Guide. (3rd edn.). London: Sage Publications.

Lietz, CA., Langer, C.L. and Furman, R. (2006). Establishing trustworthiness in qualitative research in social work. *Qualitative Social Work,* 5(4), pp.441-458.

Lincoln, Y. and Guba, E. (1985). *Naturalistic Inquiry.* Newbury Park, CA: Sage Publications.

Lindvall, J. (2016). *Supporting instructional improvement at scale: The role of teacher professional development programs and mathematics curriculum materials*. Doctoral dissertation, Mälardalen University.

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

Lindvall, J. and Ryve, A. (2019). Coherence and the Positioning of Teachers in Professional Development Programs. A Systematic Review*. Educational Research Review*, 27, pp.140-154.

Lingam, G., Lingam, N. and Sharma, L. (2017). Educational reforms and implications on teachers' world of work: Perspectives of Fijian primary teachers. *Australian Journal of Teacher Education*, 42(1), pp.19-35.

Lipowsky, F., Rakoczy, K., Pauli, C., Drollinger-Vetter, B., Klieme, E. and Reusser, K. (2009). Quality of geometry instruction and its short-term impact on pupils' understanding of the Pythagorean theorem. *Learning and Instruction*, 19(6), pp. 527-537.

Liston, D., and Zeichner, K. (1991). *Teacher education and the social conditions of schooling*. New York: Routledge.

Liston, M. (2015). The use of video analysis and the Knowledge Quartet in mathematics teacher education programmes. *International Journal of Mathematical Education in Science and Technology*, 46(1), pp.1-12.

Liu, K. (2015). Critical reflection as a framework for transformative learning in teacher education. *Educational Review*, 67 (2), pp.135-157.

Liu, Q., Ba, S., Huang, J., Wu, L. and Lao, C. (2017). A Study on Grouping Strategy of Collaborative Learning Based on Clustering Algorithm. *In International Conference on Blended Learning,* pp. 284-294. Cham: Springer.

Livy, S. and Herbert, S. (2013). Second-Year Pre-Service Teachers' Responses to Proportional Reasoning Test Items. *Australian Journal of Teacher Education*, 38(11), pp.17-32.

Livy, S. and Vale, C. (2011). First year pre-service teachers' mathematical content knowledge: Methods of solution for a ratio question. *Mathematics Teacher Education and Development*, 13(2), pp.22-43.

Livy, S., Vale, C. and Herbert, S. (2016). Developing primary pre-service teachers' mathematical content knowledge during practicum teaching. *Australian Journal of Teacher Education*, 41(2), pp.152-173.

Llinares, S. and Krainer, K. (2006). Mathematics (pupil) teachers and teacher educators as learners. In A. Gutie´rrez and P. Boero (eds.), *Handbook of Research on the Psychology of Mathematics Education,* pp.429-459. Rotterdam, The Netherlands: Sense Publishers.

Locke, S. (2016). *The effects of the RIDE strategy on teaching word problem-solving skills to pupils with learning disabilities*. Theses and Dissertations. 1485. Available online at: https://rdw.rowan.edu/etd/1485 [Accessed on 10th February 2018].

Lomibao, L.S. (2016). Enhancing mathematics teachers' quality through Lesson Study. *Springer Plus*, 5(1), p.1590.

Loucks-Horsley, S., Love, N., Stiles. K.E., Mundry, S. and Hewson, P.W. (2010). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.

Loughran, J. (2002). Effective Reflective Practice. In search of meaning about teaching. *Journal of Teacher Education,* 53(1), pp.33-43.

Loughran, J., Berry, A. and Mulhall, P. (2012). *Understanding and developing science teachers' pedagogical content knowledge*. Netherlands: Sense Publishers.

Lowe, M. (2007). *Beginning Research. A guide for foundation degree pupils.* London: Routledge.

Lowe, M. (2013). Active Learning. In Capel, S., Leask, M. and Turner, T., (6th edn.). *Learning to teach in the secondary school. A companion to school experience,* pp.325-344. London: Routledge

Lubin, J., and Polloway, E.A. (2016). Mnemonic instruction in science and social studies for pupils with learning problems: A review. Learning Disabilities. *A Contemporary Journal*, 14(2), pp.207-224.

Lui, C. and Matthews, R. (2005). Vygotsky's philosophy: Constructivism and its criticisms examined. *International Educational Journal,* 6(3), pp.386-399.

Lumpkin, A. (2007). Caring teachers: The key to student learning. *Kappa Delta Pi Record*, 43(4), pp.158–160.

Lushen, K., Kim, O., and Reid, R. (2012). Paraeducator-led strategy instruction for struggling writers. *Exceptionality*, 20(4), pp.250-265.

Ma, L. (1999). *Knowing and teaching elementary mathematics: teachers' understanding of fundamental mathematics in China and the United States*. New Jersey: Lawrence Erlbaum.

Maccini, P. and Ruhl, K.L. (2000). Effects of graduated instructional sequence on the algebraic subtraction of integers by secondary students with disabilities. Education and Treatment of Children, 23, pp.465-489.

Maccini, P. and Hughes, C.A. (2000). Effects of a problem-solving strategy on the introductory algebra performance of secondary students with learning disabilities. Learning Disabilities Research & Practice, 15(1), pp.10-21.

Machin, S. and Vignoles, A. (2006). *Education Policy in the UK*. CEE DP 57. *Centre for the Economics of Education*. London: London School of Economics and Political Science.

Machida, K., and Carlson, J.S. (1984). Effects of a verbal mediation strategy on cognitive processes in mathematics learning. *Journal of Educational Psychology,* 76(6), pp.1382-1385.

MacLeod, J., Yang, H.H., Zhu, S. and Li, Y. (2018). Understanding pupils' preferences toward the smart classroom learning environment: Development and validation of an instrument. *Computers and Education*, 122, pp.80-91.

MacNaughton, G., Rolfe, S.A., and Siraj, I. (2020). *Doing early childhood research: International perspectives on theory and practice.* London: Routledge

Mädamürk, K., Kikas, E., and Palu, A. (2016). Developmental trajectories of calculation and word problem solving from third to fifth grade. *Learning and Individual Differences*, 49, pp.151-161.

Maguire, M. and Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *AISHE-J. The All Ireland Journal of Teaching and Learning in Higher Education*, 9(3), p.335.

Maksimovic, J. and Osmanovic, J. (2018). Reflective Practice as a Changing Factor of Teaching Quality. *Research in Pedagogy*, 8(2), pp.172-189.

Mallick, L., Das, P.K., and Pradhan, K.C. (2016). Impact of educational expenditure on economic growth in major Asian countries: Evidence from econometric analysis. *Theoretical and Applied Economics*, 2(607), pp.173-186.

Marcos, J.J.M., Miguel, E.S. and Tillema, H. (2009). Teacher reflection on action: What is said (in research) and what is done (in teaching). *Reflective Practice*, 10(2), pp.191-204.

Martin, M.P. (2010). *2004-2009 National Assessment Report*. Victoria: *Sustainability for Seychelles.*

Martínez, G. and Mellado, V. (2016). The importance of PCK in the education of secondary school physics teachers: A case study on teaching electric fields. *Secondary education: perspectives, global issues and challenges*, pp.2-27.

Ma'rufi, M.R. and Ilyas, M. (2019). Pedagogical content knowledge (PCK) among mathematics teachers on function materials through lesson study in junior high school. *International Journal of Innovation, Creativity and Change*, 9(1), pp.135-156.

Masingila, J.O., Olanoff, D. and Kimani, P.M. (2018). Mathematical knowledge for teaching teachers: knowledge used and developed by mathematics teacher educators in learning to teach via problem solving. *Journal of Mathematics Teacher Education*, 21(5), pp.429-450.

Mastropieri, M. A., and Scruggs, T.E. (1998). Enhancing school success with mnemonic strategies. *Intervention in School and Clinic*, 33, pp.201-208.

Mason, J. (2018). *Qualitative researching*, (3rd edn.). London: Sage Publications.

Maat, S.M.B. and Zakaria, E. (2010). An Exploration of Mathematics Teachers' Reflection on Their Teaching Practices. *Asian Social Science*, 6(5), p.147.

Mathew, N.G. (2012). Reflective classroom practice for effective classroom instruction. *International Education Studies*, 5(3), pp.205-211.

Mathew, P. and Peechattu, P. (2017). Reflective Practices: A means to teacher development. *Asia Pacific Journal of Contemporary Education and Communication Technology (APJCECT)*, 3(1), pp.126-131.

Malmberg, L.-E., Hagger, H. and Webster, S. (2014). Teachers' situation-specific mastery experiences: Teacher, student group and lesson effects. *European Journal of Psychology of Education*, 29(3), pp.429-451.

Mawanda (2016). Underperformance in schools. *Today in Seychelles*, 25th January, p.1.

Maxwell, J.A. (2006). Literature reviews of, and for, educational research: A commentary on Boote and Beile's "Scholars before researchers". *Educational Researcher*, 35(9), pp.28-31.

Maxwell, J.A. (2013). *Qualitative research design: An interactive approach*. Thousand Oaks, CA: Sage Publications.

McCabe, J.A., Osha, K.L. and Roche, J.A. (2013). Psychology pupils' knowledge and use of mnemonics. *Teaching of Psychology*, 40(3), pp.183-192.

McCray, J.S., and Chen, J.Q. (2012). Pedagogical Content Knowledge for Preschool Mathematics: Construct Validity of a New Teacher Interview. *Journal of Research in Childhood Education*, 26(3), pp.291-30.

McCrory, R., Floden, R., Ferrini-Mundy, J., Reckase, M.D. and Senk, S.L. (2012). Knowledge of algebra for teaching: A framework of knowledge and practices. *Journal for Research in Mathematics Education*, 43(5), pp.584-615.

McDuffie, A.R. (2004). Mathematics teaching as a deliberate practice: An investigation of elementary pre-service teachers' reflective thinking during pupil teaching. *Journal of Mathematics Teacher Education*, 7(1), pp.33-61.

Mears, C. (2017). In-depth Interviews. In R. Coe, M. Waring, L. Hedges and J. Arthur, (eds.), *Research Methods and Methodologies in Education*, (2nd edn.), p.186. London: Sage Publications.

Mellone, M., Verschaffel, L., and Van Dooren, W. (2017). The effect of rewording and dyadic interaction on realistic reasoning in solving word problems. *The Journal of Mathematical Behaviour*, 46, pp.1-12.

Mercan, M. and Sezer, S. (2014). The effect of education expenditure on economic growth: The case of Turkey. *Procedia-Social and Behavioral Sciences*, 109, pp.925-930.

Mercer, C.D. and Miller, S.P. (1992). *Multiplication facts 0 to 81*. Lawrence, KS: Edge Enterprises.

Mercer, C.D., Mercer, A.R. and Pullen, P.C. (2011). *Teaching pupils with learning problems,* (8th edn.). Upper Saddle River, NJ: Pearson Education.

Merriam, S. (1998). *Case Study Research in Education. A Qualitative Approach*. San Francisco, CA: Josey-Bass.

Merriam, S., Caffarella, R. and Baumgartner, L. (2007). *Learning in adulthood: A comprehensive guide,* (*4*th edn.). San Francisco, CA: Jossey-Bass.

Merriam, S. B. (2009). *Qualitative research A guide to design and implementation.* San Francisco, CA: Jossey-Bass.

Metzler, J. and Woessmann, L. (2012). The impact of teacher subject knowledge on pupil achievement: Evidence from within-teacher within-pupil variation. *Journal of Development Economics*, 99(2), pp.486-496.

Mezirow, J and Associates. (1990). *Fostering critical reflection in adulthood*. San Francisco, CA: Jossey-Bass.

Mezirow, J (1996). Contemporary paradigms of learning, *Adult Education Quarterly*, 46(3), pp.158-173.

Mezirow, J. (1978). Perspective transformation*. Adult Education Quarterly*, 28(2), pp.100-110.

Mezirow, J., and Marsick, V.J. (1979). *Education for perspective transformation: Women's re-entry programs in community colleges.* Washington, DC: U.S. Dept. of Health.

Mezirow, J. (1991). *Transformative dimensions of adult learning*. San Francisco, CA: Jossey-Bass.

Mezirow, J. (1997). Transformative learning: Theory to practice. *New Directions for Adult and Continuing Education.* 74, pp.5-12.

Mezirow, J. (2000). Learning to think like an adult. In J. Mezirow and Associates (eds.), *Learning as a transformation: Critical perspectives on a theory in progress*, pp.3-35. San Francisco: Jossey-Bass.

Mezirow, J. (2006). An overview of transformative learning. In P. Sutherland and J. Crowther (eds.), *Lifelong learning: Concepts and contexts*, pp. 24-38. New York: Routledge.

Mezirow, J. (2009). Transformative learning theory. In J. Mezirow, E.W. Taylor and Associates (eds.), *Transformative Learning in Practice: Insights from Community, Workplace and Higher Education,* pp.18-31. San Francisco, CA: Jossey-Bass.

Mezirow, J. and Taylor, E.W. (2009). *Transformative learning in practice*. San Francisco, CA: Jossey-Bass.

Mezirow, M. (2003). Transformative learning as discourse. *Journal of Transformative Education*, 1(1), pp.58-63.

Middleton, R. (2017). Critical reflection: the struggle of a practice developer. *International Practice Development Journal 7*, 1 (4), pp.1-6.

Miles, M., Huberman, M. and Saldana, J. (2014). *Qualitative data analysis: A methods sourcebook*, (3rd edn.). London: Sage Publications.

Miller, S.P. and Strawser, S. (1996). Promoting strategic maths performance among pupils with learning disabilities. *LD Forum*, 21(2), pp.34-40.

Miller, G., and Obara, S. (2017). Finding meaning in mathematical mnemonics. *Australian Mathematics Teacher, The*, 73(3), pp.13-18.

Mingke, G.P. and Alegre, E.M. (2019). Difficulties Encountered in Mathematical Word Problem Solving of The Grade Six Learners. *International Journal of Scientific and Research Publications*, 9(6), pp.336-345.

Minor, L.C., Onwuegbuzie, A.J., Witcher, A.E. and James, T. (2002). Preservice teachers' educational beliefs and their perception of characteristics of effective teachers. *The Journal of Educational Research,* 96(2), pp.116-127.

MOE (1984). *Education for a new society.* Victoria: Ministry of Education.

MOE (2005). *Mathematics Working Group: Report of a research on five selected aspects of the mathematics education curriculum in Seychelles*. Victoria: Ministry of Education.

MOE (2009). *The Seychelles Education and Training System. Education Reform Action Plan (2009)*. Victoria: Ministry of Education.

MOE (2011). *The Seychelles Framework for Early Childhood Care and Education. Winning for children: A shared commitment*. Victoria: Ministry of Education.

MOE (2014a). *Report on P6 National Examinations 2013.* Victoria: Ministry of Education.

MOE (2014). *Education Sector Medium Term Strategic Plan 2013-2017 and Beyond. A Road Map for the Further Transformation of the Education Process to Achieve Quality Lifelong Education for All and Improve National Sustainable Development*. Victoria: Ministry of Education.

MOE (2015). *National EFA 2015 Review Report.* Victoria: Ministry of Education.

Monk, D.H. (1989). The education production function: Its evolving role in policy analysis. *Educational Evaluation and Policy Analysis*, 11(1), pp.31-45.

Morin, L.L., Watson, S.M.R., Hester, P. and Raver, S. (2017). The Use of a Bar Model Drawing to Teach Word Problem-solving to Students with Mathematics Difficulties. *Learning Disability Quarterly*, 40(2), pp.1-14.

Morris, A.K., Hiebert, J. and Spitzer, S.M. (2009). Mathematical knowledge for teaching in planning and evaluating instruction: What can preservice teachers learn? *Journal for Research in Mathematics Education*, 40(5), pp.491-529.

Morris, D.B., Usher, E.L. and Chen, J.A. (2017). Reconceptualising the sources of teaching self-efficacy: A critical review of emerging literature. *Educational Psychology Review*, 29(4), pp.795-833.

Moru, E., Qhobela, M. and Maqutu, T. (2014). The impact of instruction in enhancing teachers' knowledge of teaching mathematics in some Lesotho primary schools. *Teacher Development*, 18(2), pp.246-263.

Moscardini, L. (2014). Developing equitable elementary mathematics classrooms through teachers learning about children's mathematical thinking: Cognitively Guided Instruction as an inclusive pedagogy. *Teaching and Teacher Education,* 43, pp.69-79.

Mosvold, R. and Fauskanger, J. (2014). Teachers' Beliefs about Mathematical Horizon Content Knowledge. *International Journal for Mathematics Teaching and Learning*, 9(3), pp.311-327.

Moyer-Packenham, P.S. and Westenskow, A. (2012). Processes and Pathways: How Do Mathematics and Science Partnerships Measure and Promote Growth in Teacher Content Knowledge? *School Science and Mathematics*, 112(3), pp.133-146.

Mundia, L. and Metussin, H. (2019). Exploring factors that improve mathematics achievement in Brunei. *Studies in Educational Evaluation,* 60, pp.214-222.

Mupa, P. and Chinooneka, T.I. (2015). Factors Contributing to Ineffective Teaching and Learning in Primary Schools: Why Are Schools in Decadence? *Journal of Education and Practice*, 6(19), pp.125-132.

Myers, M.D. and Avison, D.E. (2002). An introduction to qualitative research in information systems. In M.D. Myers and D.E. Avison (eds.), *Qualitative Research in Information Systems,* pp.3-12. London: Sage Publications.

Nason, R., Chalmers, C. and Yeh, A. (2012). Facilitating growth in prospective teachers' knowledge: teaching geometry in primary schools. *Journal of Mathematics Teacher Education*. 15 (3), pp.227-249.

National Bureau of Statistics (2019). *Population and Vital Statistics*. Victoria: Seychelles Catalogue Number: EMP2019/Q1. 28th June 2019.

NCTM (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: NCTM.

Nelson, G. and Powell, S.R. (2018). A systematic review of longitudinal studies of mathematics difficulty. *Journal of Learning Disabilities*, 51(6), pp.523-539.

Nerstrom, Norma. (2014). An Emerging Model for Transformative Learning, Adult Education Research Conference. Available at: http://newprairiepress.org/aerc/2014/papers/55 [Accessed on 24th September 2018].

Newman, M. (2012). Calling transformative learning in question: Some mutinous thoughts. *Adult Education Quarterly*, 62(1), pp.36-55.

Newton, K.J., Leonard, J., Evans, B.R. and Eastburn, J.A. (2012). Preservice elementary teachers' mathematics content knowledge and teacher efficacy. *School Science and Mathematics*, 112(5), pp.289-299.

Ngo, F.J. (2012). The distribution of pedagogical content knowledge in Cambodia: Gaps and thresholds in math achievement. *Educational Research for Policy and Practice*, 12(2), pp.81-100.

Ni, L.B., and Hassan, N.A.B. (2019). The Use of Mnemonic and Mathematical Mnemonic Method in Improving Historical Understanding. *World Academy of Science, Engineering and Technology International Journal of Educational and Pedagogical Sciences*, 13(2), pp.93-97.

Ní Shúilleabháin, A. (2015b). Developing Mathematics Teachers' Pedagogical Content Knowledge Through Iterative Cycles of Lesson Study. CERME 9 - *Ninth Congress of European Research in Mathematics Education,* pp.2734-2740.

Ní Shúilleabháin, A. and Clivaz, S. (2017). Analyzing teacher learning in lesson study: Mathematical knowledge for teaching and levels of teacher activity. *Quadrante: Revista de Investigacao em Educacao Matematica*, 26(2), pp.99-125.

Ní Shúilleabháin, A. (2016). Developing mathematics teachers' pedagogical content knowledge in lesson study: Case study findings. *International Journal for Lesson and Learning Studies*, 6(3), pp.212-226.

Ní Shúilleabháin, A. (2015). Lesson Study as a form of in-School Professional. Available online at:https://www.ncca.ie/media/2136/lesson-study-pdf [Accessed on 7th July, 2016].

Nilsson, P. and Karlsson, G. (2019). Capturing pupil teachers' pedagogical content knowledge (PCK) using CoRes and digital technology. *International Journal of Science Education*, 41(4), pp.419-447.

Nind, M. (2020). A new application for the concept of pedagogical content knowledge: teaching advanced social science research methods. *Oxford Review of Education*, 46(2), pp.185-201.

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

Nolan, B., Dempsey, M., Lovatt, J. and O'Shea, A. (2015). Developing Mathematical Knowledge for Teaching (MKT) for pre-service teachers: a study of pupils' developing thinking in relation to the teaching of mathematics. *Proceedings of the British Society for Research into Learning Mathematics*, 35(1), pp.54-59.

Norton, S.J. (2017). Primary Mathematics Trainee Teacher Confidence and its Relationship to Mathematical Knowledge. *Australian Journal of Teacher Education*, 42(2), pp.47-61.

Nowell, L.S., Norris, J.M., White, D.E. and Moules, N.J. (2017). Thematic Analysis: Striving to Meet the Trustworthiness Criteria. *International Journal of Qualitative Methods*, 16(1), pp.1-13.

Nyagah, G and Gathumbi, A. (2017). Influence of teacher characteristics on the implementation of non-formal basic education curriculum at the non-formal education centres in Nairobi, Mombasa and Kisumu Cities, Kenya. *International Journal of Education and Research*, 5(1), pp.207-221.

Odumosu, O., and Fisayi, A. (2018). Teachers' content and pedagogical knowledge on students' achievement in algebra. *International Journal of Education and Research*, 6(3), pp.83-94.

OECD (2016). *Low-Performing Students: why they fall behind and how to help them succeed*. Available online at: https://www.oecd-ilibrary.org/education/low-performing-pupils_9789264250246-en [Accessed on 16th March 2018].

OECD (2016). Result for PISA 2015. Available online at: https://www.oecd.org/pisa/PISA-2015-United-Kingdom.pdf [Accessed: 19th March 2019].

OECD (2017). OECD work on education and skills. *Directorate for Education and Skills Brochure*. Available online at: [http://www.oecd.org/education/Directorate-for-education-and-skills-brochure.pdf [Accessed on 16th March 2018].

OECD (2018a). Effective teacher policies: insights from PISA. *OECD.* Available online at: https://www.oecd-ilibrary.org/ [Accessed on 20th April 2019].

OECD (2018b). PISA 2018 results. *OECD*. Available online at: https://www.oecd.org/pisa/publications/pisa-2018-results.htm [Accessed on 13th December 2018].

OECD (2018c). The future of education and skills: *Education 2030*. *OECD.*

OECD (2019a). PISA 2018 Results (Volume I): What Students Know and Can Do, PISA. Paris: OECD Publishing. Available online at: https://doi.org/10.1787/5f07c754-e [Accessed on 8th October 2019].

Olson, J.D., McAllister, C., Grinnell, L.D., Gehrke Walters, K. and Appunn, F. (2016). Applying Constant Comparative Method with Multiple Investigators and Inter-Coder Reliability. *The Qualitative Report*, 21(1), pp.26-42.

Opfer, D. and Pedder, D. (2011). Conceptualising teacher professional learning. *Review of Educational Research*, 81(3), pp.376-407.

Osaat, S.D. and Okenwa, U. (2018). Feminisation of primary school teaching: A societal and cultural limitation to boy-child education. *International Journal of Education and Evaluation*, 4(2), pp.1-10.

Osman, S., Yang, C.N.A C., Abu, M.S., Ismail, N., Jambari, H. and Kumar, J.A. (2018). Enhancing pupils' mathematical problem-solving skills through bar model visualisation technique. *International Electronic Journal of Mathematics Education*, 13(3), pp.273-279.

Osterman, K.F. and Kottkamp, R.B. (1993). *Reflective practice for educators*. Newbury Park, CA: Corwin Press.

Ottmar, E, Rimm-Kaufman, S., Larsen, R. and Berry, R. (2015). Mathematical Knowledge for Teaching, Standards-Based Mathematics Teaching Practices, and Student Achievement in the Context of the Responsive Classroom Approach. *American Educational Research Journal,* 52(4), pp.787-821.

Owen, M.J. (2003). *It's elementary! 275 math word problems book 3*. Toronto, Canada: Educator Publishing Service.

Palmer, D. (2011). Sources of efficacy information in an in-service program for elementary teachers. *Science Education*, 95(4), pp.577-600.

Park, M.S., Kim, Y.R., Moore, T.J. and Wyberg, T. (2018). Professional development framework for secondary mathematics teachers. *International Journal of Learning, Teaching and Educational Research*, 17(10), pp.127-151.

Parra, M.O., Gutiérrez, R. and Aldana, M.F. (2016). Engaging in critically reflective teaching: from theory to practice in pursuit of transformative learning. *Reflective Practice: International and Multidisciplinary Perspectives*, 16(1), pp.16-30.

Paterson, C., and Chapman, J. (2013). Enhancing skills of critical reflection to evidence learning in professional practice. *Physical Therapy in Sport*, 14(3), pp.133-138.

Patrick, F. (2013). Neoliberalism, the knowledge economy, and the learner: Challenging the inevitability of the commodified self as an outcome of education. *ISRN Education*, pp.1-8.

Patton, M. (2015). *Qualitative evaluation and research methods,* (5th edn.). Thousand Oaks, CA: Sage Publications.

Percy, W.H., Kostere, K. and Kostere, S. (2015). Generic qualitative research in psychology. *The Qualitative Report,* 20(2), pp.76-85.

Peters, M.L. (2013). Examining the relationships among classroom climate, self-efficacy, and achievement in undergraduate mathematics: A multi-level analysis. *International Journal of Science and Mathematics Education*, 11(2), pp.459-480.

Petrou, M. and Goulding, M. (2011). Conceptualising teachers' mathematical knowledge in teaching. In Rowland T. and Ruthven K. (eds.). *Mathematical Knowledge in Teaching,* pp.9-25. London: Springer.

Pfitzner-Eden, F. (2016). Why do I feel more confident? Bandura's sources predict preservice teachers' latent changes in teacher self-efficacy. *Frontiers in Psychology*, 7, pp.1-16.

Phelps, G., Jones, N., Kisa, Z. and Liu, S. (2013). *Using Measures of MKT to Study and Evaluate Professional Development.* Paper presented at the National Council of Teachers of Mathematics Research Presession, Denver, CO.

Philipp, R.A. (2007). Mathematics teachers' beliefs and affect. *Second Handbook of Research on Mathematics Teaching and Learning*, 1, pp.257-315.

Piasta, S.B., Logan, J.A.R., Yeager Pelatti, C., Capps, J.L. and Petrill, S.A. (2015). Professional development for early childhood educators: Efforts to improve math and science learning opportunities in early childhood classrooms. *Journal of Educational Psychology*, 107(2), pp.407-422.

Pollard, A. (2014). *Reflective teaching in schools*. London: Bloomsbury.

Pollard, A., with Collins, J., Simco, N., Swaffield, S., Warin, J. and Warwick, P. (2005). *Reflective Teaching*, (2nd edn.). London: Continuum.

Polly, D., Martin, C., McGee, J., Wang, C., Lambert, R. and Pugalee, D. (2017). Designing Curriculum-Based Mathematics Professional Development for Kindergarten Teachers. *Early Childhood Education Journal*, 45(5), pp.659-669.

Ponce, O.A. and Pagán-Maldonado, N. (2015). Mixed methods research in education: Capturing the complexity of the profession. *International Journal of Educational Excellence,* 1(1), pp.111-135.

Ponte, J.P. and Chapman, O. (2006). Mathematics teachers knowledge and practices. In A. Gutierrez and & P. Boero (eds.), *Handbook of Research on the Psychology of Mathematics Education: Past, present and future,* pp.461-494. Rotterdam, The Netherlands: Sense.

Poom-Valickis, K. and Mathews, S. (2013). Reflecting others and own practice: An analysis of teachers' reflection skills. *Reflective Practice*, 14(3), pp.420-434.

Postholm, M.B. (2008). Teachers developing practice: Reflection as key activity. *Teaching and Teacher Education,* 24(7), pp.1717-1728.

Prince, M. (2004). Does Active Learning Work? A Review of the Research. *Journal of Engineering Education*, 93(3), p.223.

Punch and Oancea (2014). *Introduction to Research Methods in Education,* (2nd edn.). London: Sage Publications.

Putnam, A.L. (2015). Mnemonics in education: Current research and applications. *Translational Issues in Psychological Science*, 1(2), pp.130-139.

Quillen, M.A. (2004). *Relationships among prospective elementary teachers' beliefs about mathematics, mathematics content knowledge, and previous mathematics course experiences.* Doctoral dissertation, Virginia Tech.

Rabionet, S.E. (2011). How I Learned to Design and Conduct Semi-structured Interviews: An Ongoing and Continuous Journey. *The Qualitative Report*, 16(2), pp. 563-566.

Rahimi, M., and Weisi, H. (2018). Reflective practice, self-efficacy and research practice of EFL teachers: Examining possible relationships. *Issues in Educational Research,* 28(3), pp.756-780.

Rakoczy, K., Klieme, E., Drollinger-Vetter, B., Lipowsky, F., Pauli, C. and Reusser, K. (2007). Structure as a quality feature in mathematics instruction: Cognitive and motivational effects as a structured organisation of the learning environment vs. a structured presentation of learning content. In M. Prenzel (ed.), *Studies on the educational quality of schools. The final report of the DFG Priority Programme*, pp.101-120. Muenster, Germany: Waxmann.

Raymond, A.M. (1997). Inconsistency between a beginning elementary school teacher's mathematics beliefs and teaching practice. *Journal for Research in Mathematics Education*, 28, pp.550-576.

Reid, M. and Reid, S. (2017). Learning to be a math teacher: What knowledge is essential? *International Electronic Journal of Elementary Education*, 9(4), pp.851-872.

Ren, L and Smith. W. (2013). Change in teachers' mathematics beliefs after participating in professional development. *Teacher Education and Knowledge*: Brief research report, pp.857-860.

Reynolds, D., Sammons, P., De Fraine, B., Van Damme, J., Townsend, T., Teddie, C. and Stringfield, S. (2014). Educational effectiveness research (EER): A state-of-the-art review. *School Effectiveness and School Improvement*, 25(2), pp.197-230.

Ribeiro, R.M. and Powell, A.B. (2019). Mathematical modeling and teachers' formation: a discussion on mathematical knowledge for teaching. *Revista de Educação Matemática, São Paulo*, 16(21), pp.5-17.

Rice, H and Kitchel. T. (2015). The Relationship between Agriculture Knowledge Bases for Teaching and Sources of Knowledge. *Journal of Agricultural Education*, 56(4), pp.153-168.

Richards, J.C. and Lockhart, C. (1996). *Reflective teaching in second language classrooms*. Cambridge: Cambridge University Press.

Richardson, G.M., Byrne, L.L. and Liang, L.L. (2018). Making learning visible: Developing preservice teachers' pedagogical content knowledge and teaching efficacy beliefs in environmental education. *Applied Environmental Education and Communication*, 17(1), pp.41-56.

Ritchie, J., Lewis, J.. and Elam, G. (2003). Designing and selecting samples. In J. Ritchie and J. Lewis (eds.), *Qualitative research practice. A guide for social science pupils and researchers.* pp.77-108. Thousand Oaks, CA: Sage Publications.

Rittle-Johnson, B., Schneider, M. and Star, J. R. (2015). Not a one-way street: Bidirectional relations between procedural and conceptual knowledge of mathematics. *Educational Psychology Review*, 27(4), pp.587-597.

Rockoff, J.E., Jacob, B.A., Kane, T.J. and Staiger, D.O. (2011). Can you recognise an effective teacher when you recruit one? *Education Finance and Policy*, 6(1), pp.43-74.

Rodriguez, J.A., Condom-Bosch, J. L., Ruiz, L. and Oliver, E. (2020). On the Shoulders of Giants: Benefits of Participating in a Dialogic Professional Development Program for In-Service Teachers. *Frontiers in Psychology*, 11, p. 5.

Roediger, H.L. (1980). The effectiveness of four mnemonics in ordering recall. *Journal of Experimental Psychology*. *Human Learning and Memory*, 6(5), pp.558-567.

Rogers, R.R. (2001). Reflection in higher education: A concept analysis. *Innovative Higher* Education, 26(1), pp.37-57.

Rolfe, G. (2004). Validity, trustworthiness and rigour: quality and the idea of qualitative research. *Journal of Advanced Nursing,* 53(3), pp.304-310.

Rolfe, G., Jasper, M. and Freshwater, D. (2010). *Critical Reflection In Practice: Generating Knowledge for Care,* (2nd edn.). Basingstoke: Palgrave Macmillan.

Ronfeldt, M., Loeb, S. and Wyckoff, J. (2013). How teacher turnover harms pupil achievement. *American Educational Research Journal*, 50(1), pp.4-36.

Ross, J. A. (1998). The antecedents and consequences of teacher efficacy. *Advances in Research on Teaching*, 7, pp.49-73.

Ross, J.A. and Bruce, C.D. (2007). Teacher self-assessment: a mechanism for facilitating professional growth. *Teaching and Teacher Education*, 23(2), pp.146-159.

Ross, L. and Matthews, B. (2010). *Research Methods: A practical guide for social Science*. New York: Pearson Longman.

Rossouw, L. and Smith, E. (1998). Teachers' pedagogical content knowledge of geometry. In A. Olivier and K. Newstead (eds.), *Proceedings of 22nd PME International Conference*, 4, pp.57-63.

Roth, K.J., Garnier, H.E., Chen, C., Lemmens, M., Schwille, K. and Wickler, N.I.Z. (2011). Videobased lesson analysis: Effective science PD for teacher and pupil learning. *Journal on Research in Science Teaching,* 48(2), pp.117-148.

Rowan, B., Correnti, R. and Miller, R. (2002). What large-scale, survey research tells us about teacher effects on pupil achievement: Insights from the prospects study of elementary schools. *Teachers College Record*, 104(8), pp.1525-1567.

Rowland, T., Huckstep, P. and Thwaites, A. (2005). Elementary teachers' mathematics subject knowledge: The knowledge quartet and the case of Naomi. *Journal of Mathematics Teacher Education*, 8(3), pp.255-281.

Rowland, T., Turner, F., Thwaites, A. and Huckstep, P.(2009). *Developing primary mathematics teaching: Reflecting on practice with the knowledge quartet*. London: Sage Publications.

Russo, J. (2019). Walking the Line between Order and Chaos: A Teacher-Researcher's Reflection on Teaching Mathematics with Challenging Tasks in Primary Classrooms. *International Journal of Innovation in Science and Mathematics Education*, 27(3), pp.14-24.

SACMEQ (2005). The SACMEQ II Project in Seychelles - A study of the Conditions of Schooling and the Quality of Education. Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ), South Africa. Available online at: http://www. sacmeq.org [Accessed on 8th November 2014].

Saeed, M., Tahir, H., and Latif, I. (2018). Teachers' Perceptions about the Use of Classroom Assessment Techniques in Elementary and Secondary Schools. *Bulletin of Education and Research*, 40(1), pp.115-130.

Sagor, R.D. (2011). *The action research guidebook: A four-stage process for educators and school teams,* (2nd edn.). Thousand Oaks, CA: Corwin Press.

Sahin, M., Erisen, Y., and Çeliköz, N. (2016). The Transformational Learning of Three Adult Academicians. *Online Submission*, 6(1), pp.299-30.

Salīte, I., Drelinga, E., Iliško, D., Oļehnoviča, E., and Zariņa, S. (2016). Sustainability from the transdisciplinary perspective: An action research strategy for continuing education program development. *Journal of Teacher Education for Sustainability*, 18(2), pp.135-152.

Sandefur, J. (2018). Internationally Comparable Mathematics Scores for Fourteen African. *Education of Economics Review*, 62, pp.267-286.

Santalucia, S. and Johnson, C. (2010). Transformative learning: Facilitating growth and change through fieldwork. *OT Practice*, 15(19), pp.1-8.

Sapire, I. and Sorto, M. A. (2012). Analyzing teaching quality in Botswana and South Africa. *Prospects*, 42(4), pp.433-451.

Sartain, P. (2015). *An exploration of the effectiveness of reflective practice on adult learning*, pp.1-17. Available online at: https://codapartners.net/wp-content/uploads/2018/05/Reflective-Practices-White-Paper-CODA-1.pdf [Accessed on 10th May 2015].

Savin-Baden, M. and Major C.H. (2013). *Qualitative Research. The essential guide to theory and practice*. London: Routledge.

Sayed, Y. and Kanjee, A. (2013). Assessment in Sub-Saharan Africa: Challenges and prospects. *Assessment in Education: Principles, Policy and Practice*, 20(4), pp.373-384.

Schoenfeld, A. (2002). A Highly Interactive Discourse Structure. In J. Brophy (ed.) Social Constructivist Teaching: Affordances and Constraints. *Advances in Research on Teaching,* 9, p.131-169, Atlanta, GA: Elsevier.

Schoenfeld, A.H. (2007). The complexities of assessing teacher knowledge*. Measurement: Interdisciplinary Research and Perspectives*, 5(2), pp.198-204.

Schoenfeld, A.H. (2010). *How we think: A theory of goal-oriented decision making and its educational applications.* New York: Routledge.

Schön, D.A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Schön, D.A. (1987). *Educating the reflective practitioner*. San Fransisco, CA: Jossey-Bass.

Scruggs, T.E. and Mastropieri, M.A. (1990). Mnemonic instruction for pupils with learning disabilities: What it is and what it does. *Learning Disability Quarterly*, 13(4), pp.271-280.

Scruggs, T.E. and Mastropieri, M.A. (1991). Classroom applications of mnemonic instruction: Acquisition, maintenance, and generalisation. *Exceptional Children*, 58(3), pp.219-229.

Scruggs, T.E., Mastropieri, M.A., Berkeley, S.L. and Marshak, L. (2010). Mnemonic strategies: Evidence-based practice and practice-based evidence. *Intervention in School and Clinic*, 46(2), pp.79-86.

Scruggs, T.E., Mastropieri, M.A., Berkeley, S.L., and Marshak, L. (2010). Mnemonic strategies: Evidence-based practice and practice-based evidence. *Intervention in School and Clinic*, 46(2), pp.79-86.

Seitova, M. (2019). Student teachers' perceptions of reflective practice. *International Online Journal of Education and Teaching*, 6(4), pp.765-772.

Sellars, M. (2012). Teachers and change: The role of reflective practice. *Procedia-Social and Behavioural Sciences*, 55, pp.461-469.

Seychelles Nation (5th April 2013). The Story of Schools in the Seychelles. Available online at: http://www.nation.sc/article.html?id=238140 [Accessed: 20th March 2019].

Seychelles Nation (10th February 2017*).* Boosting the teaching of mathematics in primary schools with ‘Cracking Maths’. Available online at: http://www.nation.sc/archive/252851/boosting-the-teaching-of-mathematics-in-primary-schools-with-cracking-maths [Accessed on 15th February 2017].

Shah, M. (2012). The importance and benefits of teacher collegiality in schools – A literature review. *Procedia-Social and Behavioural Sciences*, 46, pp.1242-1246.

Sharples, J., Webster, R. & Blatchford, P. (2015). EEF guidance report: making best use of teaching assistants. London: The Education Endowment Foundation. Available online at: https://educationendowmentfoundation.org.uk/uploads/pdf/TA_Guidance_Report_Interactive.pdf [Accessed on 15th July 2021].

Sherin, M.G. (2002). When Teaching Becomes Learning. *Journal of Cognition and Instruction*, 20(2), pp.119-150.

Shillington, K. (2009). *History of Modern Seychelles*. Oxford: Macmillan.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), pp.4-14.

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), pp.1-22.

Siegler, R.S., Duncan, G.J., Davis-Kean, P.E., Duckworth, K., Claessens, A., Engel, M. and Chen, M. (2012). *Early predictors of high school mathematics achievement. Psychological Science*, 23(7), pp.691-697.

Silver, E.A., Clark, L.M., Ghousseini, H.N., Charalambous, C.Y. and Sealy, J.T. (2007). Where is the mathematics? Examining teachers' mathematical learning opportunities in practice-based professional learning tasks. *Journal of Mathematics Teacher Education*, 10(4–6), pp.261-277.

Silverman, J. and Thompson, P.W. (2008). Toward a framework for the development of mathematical knowledge for teaching. *Journal of Mathematics Teacher Education*, 11(6), pp.499-511.

Sinatra, G.M. and Kardash, C.A.M. (2004). Teacher candidates' epistemological beliefs, dispositions, and views on teaching as persuasion. *Contemporary Educational Psychology*, 29(4), pp.483-498.

Sirait, S. (2016). Does teacher quality affect pupil achievement? An empirical study in Indonesia. *Journal of Education and Practice*, 7(27), pp.34-41.

Siswono, T.Y.E., Kohar, A.W. and Hartono, S. (2019). Beliefs, knowledge, teaching practice: three factors affecting the quality of teacher's mathematical problem-solving. In *Journal of Physics: Conference Series* (Vol. 1317, No. 1, p. 012127). IOP Publishing. Available online at: doi:10.1088/1742-6596/1317/1/012127 [Accessed on 7th December 2019].

Siswono, T.Y.E., Kohar, A.W. and Hartono, S. (2019). Beliefs, knowledge, teaching practice: three factors affecting the quality of teacher's mathematical problem-solving. *In Journal of Physics: Conference Series,* 1317(1), p.012127.

Skaalvik, E.M. and Skaalvik, S. (2007). Dimensions of teacher self-efficacy and relations with strain factors, perceived collective teacher efficacy, and teacher burnout. *Journal of Educational Psychology*, 99(3), pp.611-625.

Skemp, R.R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77, pp.20-26.

Skemp, R.R. (1987). *The psychology of learning mathematics*. Hillsdale, NJ: Erlbaum.

Skovsmose, O. (2011). *An Invitation to Critical Mathematics Education*. Rotterdam: Sense Publishers.

Slade, M.L., Burnham, T.J., Catalana, S.M. and Waters, T. (2019). The Impact of Reflective Practice on Teacher Candidates' Learning. *International Journal for the Scholarship of Teaching and Learning*, 13(2), pp.1-8.

Smith, M. and Stein, M. (2011). *Five Practices for Orchestrating Productive Mathematics Discussions*. Reston: NCTM.

Smith, N., Lambdin, D., Lindquist, M. and Reys, R. (2009). *Helping Children Learn Mathematics, (*9th edn.). Hoboken, NJ: Wiley Press.

Smith. T, Barlow. P, Peters. J, and Skolits. G. (2015). Demystifying reflective practice: Using the DATA model to enhance evaluators' professional activities. *Evaluation and Program Planning,* 52, pp.142-147.

Solomon, J. (1987). *New thoughts on teacher education*. Oxford: Oxford Review of Education.

Speer, N.M., King, K.D. and Howell, H. (2014). Definitions of mathematical knowledge for teaching: using these constructs in research on secondary and college mathematics teachers. *Journal of Mathematics Teacher Education*, 18(2), pp.105-122.

Sriyono, H. (2018). The influence of self-confidence on the performance of social science teachers in the new kebayoran sub-district of south Jakarta, Indonesia. *International Journal of Research Science and* Unal, Z. and Unal, A. *Management*, (5)6, pp.1-4.

Stake, R. (1995). *The Art of Case Study Research*. Thousand Oaks, CA: Sage Publications.

Stallions, M., Murrill, L., and Earp, L. (2012). Don't Quit Now!: Crisis, Reflection, Growth, and Renewal for Early Career Teachers. *Kappa Delta Pi Record*, 48(3), pp.123-128.

Steele, M.D., Hillen, A.F. and Smith M.S. (2013). Developing mathematical knowledge for teaching in a methods course: the case of function. *Journal of Mathematics Teacher Education*, 16(6), pp.451-482.

Stes, A., and Van Petegem, P. (2013). Instructional development for university teachers: Causes of impact and practical implications. In E. Simon. & G. Pleschova (eds.), *Teacher development in higher education: Existing programmes, programmes impact and future trends (*pp.234–256). Routledge: London

Straub, D.W. (1989). Validating instruments in MIS research. *MIS Quarterly*, 13(2), pp.147-169.

Street, D. (1995). Controlling extraneous variables in experimental research: a researcher note. *Accounting Education,* 4(2), pp.169-188.

Strutz, T. (2010). *Data Fitting and Uncertainty: A Practical Introduction to Weighted Least Squares and beyond*. Wiesbaden: Springer.

Sudejamnong, A., Robsouk, K., Loipha, S. and Inprasitha, M. (2014). Development of Teachers' Mathematical Knowledge for Teaching by Using the Innovation of Lesson Study and Open Approach. *Sociology Mind,* 4, pp.317-327.

Suh, J. and Parker, J. (2010). Developing Reflective Practitioners through Lesson Study with Preservice and Inservice Teachers. Mathematics Teaching: Putting Research into Practice at All Levels. *AMTE Monograph,* 7, pp.125-140.

Suh, J. and Seshaiyer, P. (2015). Examining teachers' understanding of the mathematical learning progression through vertical articulation during lesson study. *Journal of Mathematics Teacher Education*, 18(3), pp.207-229.

Swars, S.L., Smith, S.Z., Smith, M.E., Carothers, J. and Myers, K. (2018). The preparation experiences of elementary mathematics specialists: Examining influences on beliefs, content knowledge, and teaching practices. *Journal of Mathematics Teacher Education*, 21(2), pp.123-145.

Swars, S., Hart, L.C., Smith, S.Z., Smith, M.E. and Tolar, T.A. (2007). Longitudinal study of elementary pre-service teachers' mathematics beliefs and content knowledge. *Elementary PreService Teachers' Mathematics*, 107(9), pp.325-335.

Symes, W., and Humphrey, N. (2011). The Deployment, Training and Teacher Relationships of Teaching Assistants Supporting Pupils with Autistic Spectrum

Disorders (ASD) in Mainstream Secondary Schools. *British Journal of Special Education*, 38(2), pp.57-64.

Taber, K.S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), pp.1273-1296.

Tai, D.W.S., Hu, Y.C., Wang, R. and Chen, J.L. (2012). What is the impact of teacher self-efficacy on the pupil learning outcome? *Networking in Engineering and Technology Education*, 77, pp.77-82.

Takahashi, S. (2011). Co-constructing efficacy: A "communities of practice" perspective on teachers' efficacy beliefs. *Teaching and Teacher Education*, 27(4), pp.732-741.

TALIS 2018 survey. Teaching and learning international survey. Available online at: http://www.oecd.org/education/school/TALIS_2018_brochure_ENG.pdf [Accessed on 11th May 2019].

Tall, D.O. (2013). *How Humans Learn to Think Mathematically*. New York: Cambridge University Press.

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

Tan, C. (2017). Constructivism and pedagogical reform in China: issues and challenges. *Globalisation, Societies and Education*, 15(2), pp.238-247.

Tatto, M.T., Schwille, J., Senk, S.L., Ingvarson, L., Rowley, G., Peck, R. et al. (2012). Policy, practice, and readiness to teach primary and secondary mathematics in 17 countries: *Findings from the IEA Teacher Education and Development Study in Mathematics (TEDS-M).* Amsterdam: IEA.

Tavakol, M. and Dennick, R. (2011). Making sense of Cronbach's Alpha. *International Journal of Medical Education*, 2, pp.53-55.

Tayan, B.M. (2017). The Saudi Tatweer Education Reforms: Implications of Neoliberal Thought to Saudi Education Policy. *International Education Studies*, 10(5), pp.61-71.

Taylor, E.W. (1997). Building upon the theoretical debate: A critical review of the empirical studies of Mezirow's transformative learning theory. *Adult Education Quarterly*, 48(1), pp.34-59.

Taylor, E.W. (2009). Fostering transformative learning. In J. Mezirow, E. Taylor and Associates (eds.), *Transformative learning in practice. Insights from community, workplace, and higher education*. San Francisco, CA: Jossey-Bass.

Taylor, E.W. (2017). Critical reflection and transformative learning: A critical review. *PAACE Journal of Lifelong Learning*, 26(2), pp.77-95.

Teddlie, C. and Tashakkori, A. (2009). *Foundations of mixed methods research: integrating quantitative and qualitative approaches in the social and behavioural sciences*. Thousand Oaks, CA: Sage Publications.

Tennant, M.C. (1993). Perspective transformation and adult development. *Adult Education Quarterly*, 44(1), pp.34-42.

Terrill, M.C., Scruggs, T. Unal, Z. and Unal, A. E., and Mastropieri, M.A. (2004). SAT vocabulary instruction for high school students with learning disabilities. *Intervention in School and Clinic*, 39(5), pp.288-294.

Test, D.W., and Ellis, M.F. (2005). The effects of LAP fractions on addition and subtraction of fractions with students with mild disabilities. *Education & Treatment of Children*, 28, pp.11–24.

Thames, M.H. and Ball, D.L. (2013). Making progress in mathematics education: Lessons learned—past, present, and future. In K. Leatham (ed.), *Vital Directions for Mathematics Education Research,* pp.15-44. New York: Springer.

Thames, M.H., Sleep, L. Bass, H. and Ball, D.L. (2008). *Mathematical knowledge for teaching (K-8): Empirical, theoretical, and practical foundations*. Paper presented at the meeting of the International Congress on Mathematics Education, Montérrey, Mexico.

Thames, M. and Ball, D.L. (2010). What math knowledge does teaching require? *Teaching Children Mathematics,* 17(4), pp.220-229.

Thanheiser, E., Browning, C.A., Moss, M., Watanabe, T. and Garza-Kling, G. (2010). Developing Mathematical Content Knowledge for Teaching Elementary School Mathematics. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, 1, pp.1-13.

The Concise Oxford English Dictionary 2011. D. Thomson (ed.), (12th edn.), p.789. England: Oxford University Press.

Thomas, G. (2017). *How to do your Research Project: A Guide For Students,* (3rd edn.). Thousand Oaks, CA: Sage Publications.

Thoonen, E.E., Sleegers, P.J., Oort, F.J., Peetsma, T.T. and Geijsel, F.P. (2011). How to improve teaching practices: The role of teacher motivation, organisational factors, and leadership practices. *Educational Administration Quarterly*, 47(3), pp.496-536.

Tight, M. (2010). The curious case of case study: a viewpoint. *International Journal of Social Research Methodology*, 13(4), pp.329-339.

Timperley, H., Wilson, A., Barrar, H. and Fung, I. (2007). *Teacher professional learning and development: Best evidence synthesis iteration*. Wellington: Ministry of Education.

Tirosh, D., Tsamir, P., Levenson, E. and Tabach, M. (2011). From preschool teachers' professional development to children's knowledge: Comparing sets. *Journal of Mathematics Teacher Education*, 14(2), pp.113-131.

Töman, U. (2017). Investigation of Reflective Teaching Practice Effect on Training Development Skills of The Pre-service Teachers. *Journal of Education and Training Studies*, 5(6), pp.232-239.

Tomsett, J. (2015). *This much I know about love over fear: Creating a culture for truly great teaching*. Carmarthen: Crown House Publishing.

Tracy, S.J. (2010). Qualitative quality: Eight 'big-tent' criteria for excellent qualitative research. *Qualitative Inquiry*, 16(10), pp.837-851.

Tripp, T. and Rich, R. (2012a). The influence of video analysis on the process of teacher change. *Teaching and Teacher Education*, 28(5), pp.728-739.

Tschannen-Moran, M. and Hoy, A.W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education*, *23*(6), pp.944-956.

Turner (2009). Identifying and developing the mathematical apprehensions of beginning primary school teachers. *Proceedings of the British Society for Research into Learning Mathematics,* 29(3), pp.91-96.

Turner, F. (2012). Using the Knowledge Quartet to develop mathematics content knowledge: the role of reflection on professional development. *Research in Mathematics Education,* 14(3), pp.253-271.

Turner, F. (2009). Growth in teacher knowledge: individual reflection and community participation. *Research in Mathematics Education*, 11(1), pp.81-82.

Tymms, P. (2017). Interventions: experiments. In: R. Coe, M. Waring, L. Hedges and J. Arthur, (eds.), *Research Methods and Methodologies in Education*, (2nd edn.), pp.227-228. London: Sage Publications.

UNESCO (2015). *Education for All 2000-2015*: Achievements and Challenges. UNESCO.

Utley, J., Moseley, C. and Bryant, R. (2005). Relationship between science and mathematics teaching efficacy of preservice elementary teachers. *School Science and Mathematics*, 105(2), pp.82-88.

Uyanık, G. (2016). Effect of environmental education based on transformational learning theory on perceptions towards environmental problems and permanency of learning. *International Electronic Journal of Environmental Education*, 6(2), pp.126-140.

Vale, C., McAndrew, A. and Krishnan, S. (2011). Connecting with the horizon: developing teachers' appreciation of mathematical structure. *Journal of Mathematics Teacher Education,* 14, pp.193-212.

Valentin, J. (2013). *Primary mathematics teaching reform in a small island developing state: the case of the Mathematics Lesson Structure in Seychelles.* PhD Thesis.

Valentine, J. C., and McHugh, C (2007). The effects of attrition on baseline comparability in randomized experiments in education: A meta-analysis. *Psychological Methods*, 12(3), pp.268-282.

Valli, L. (1997). Listening to other voices: A description of teacher reflection in the United States. *Peabody Journal of Education*, 72(1), pp.67-88.

Van den Kieboom, L. (2013). Examining the mathematical knowledge for teaching involved in pre-service teachers' reflections. *Teaching and Teacher Education*, 35, pp.146-156.

Van Driel and Berry (2012). Professional Development Focusing on Pedagogical Content Knowledge. *Educational Researcher*, 41(1), pp.26-28.

Van Driel, J. H., Verloop, N., and de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching,* 35(6), pp.673-695.

Van Manen, M. (1991). Reflectivity and the pedagogical moment: The normativity of pedagogical thinking and acting. *Journal of Curriculum Studies*, 23(6), pp.507-536.

Van Schaik, P., Volman, M., Admiraal, W. and Schenke, W. (2019). Approaches to co-construction of knowledge in teacher learning groups. *Teaching and Teacher Education*, 84, pp.30-43.

Vasquez, C. and Harvey, J. (2010). Raising Teachers' Awareness about Corrective Feedback through Research Replication. *Language Teaching Research*, 14(4), pp.421-443.

Venkat, H. and Naidoo, D. (2012). Analysing coherence for conceptual learning in a Grade 2 numeracy lesson. *Education as Change,* 16(1), pp.21-33.

Venkat, H. and 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, pp.121-130.

Veerasamy, A. K., Souza, D. D., and Lindén, R. (2018). Relationship between perceived problem-solving skills and academic performance of novice learners in introductory programming courses. *Journal of Computer Assisted Learning*, 35(2), pp.1-10.

Verloop, N., Van Driel, J. and Meijer, P. (2001). Teacher knowledge and the knowledge base of teaching. *International Journal of Educational Research*, 35(5), pp.441-461.

Vignoles, A. (2016). What is the economic value of literacy and numeracy? Basic skills in literacy and numeracy are essential for success in the labour market. *IZA World of Labou*r, (229), pp.1-10. Bonn: Forschungsinstitut zur Zukunft der Arbeit GmbH (IZA).

Von Glasersfeld, E. (1993). Questions and answers about radical constructivism. In K. Tobin (ed.), *The practice of constructivism in science education*, pp.23-38. Washington, DC: AAAS Press.

Vygotsky, I. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wager, A.A., and Stinson, D.W. (2012). *Teaching mathematics for social justice: Conversations with educators*. Reston, VA: NCTM.

Wagner, D.A. and Castillo, N.M. (2014). Learning at the bottom of the pyramid: Constraints, comparability and policy in developing countries. *Prospects*, 44(4), pp.627-638.

Wallace, M.R. (2009). Making sense of the links: Professional development, teacher practices, and pupil achievement. *Teachers College Record*, 111(2), pp.573-596.

Walshe, N. and Driver, P. (2019). Developing reflective trainee teacher practice with 360-degree video. *Teaching and Teacher Education*, 78, pp.97-105.

Wang, S. and Zhang. D. (2019). Student-centred teaching, deep learning and self-reported ability improvement in higher education: Evidence from Mainland China, *Innovations in Education and Teaching International*, 56(5), pp.581-593.

Waring, M. (2017). Finding your theoretical position. In: R. Coe, M. Waring, L. Hedges and J. Arthur, (ed.), *Research Methods and Methodologies in Education*, (2nd edn.), p.17. London: Sage Publications.

Watanabe, A. (1991). *The effects of a mathematical word problem solving strategy on problem solving performance by middle school students with mild disabilities*. Unpublished doctoral dissertation, University of Florida, Gainesville.

Waters, M. (2015). Parents and teachers should work closely together. *Today in the Seychelles,* 23rd September 2015. Available online at: https://www.facebook.com/todayinsey/posts/interview-with-professor-michael-waters-from-wolverhampton-university-parents-an/880216832016128/ [Accessed: 13th March, 2019].

Watson, A. and De Geest, E. (2012). Learning coherent mathematics through sequences of micro-tasks: Making a difference for secondary learners. *International Journal of Science and Mathematics Education*, 10(1), pp.213-235.

Watson, J. M. and Nathan, E.L. (2010). Approaching the borderlands of statistics and mathematics in the classroom: qualitative analysis engendering and unexpected journey. *Statistics Education Research Journal,* 9(2), pp.69-87.

Whitworth, B.A. and Chiu, J.L. (2015). Professional development and teacher change: The missing leadership link. *Journal of Science Teacher Education*, 26(2), pp.121-137.

Widodo, A. (2017). Teacher pedagogical content knowledge (PCK) and pupils' reasoning and wellbeing. *Journal of Physics: Conference Series,* 812(1), p.12119.

Widodo, H.P. and Ferdiansyah, S. (2018). Engaging pupil-teachers in video-mediated self-reflection in teaching. In K.J. Kennedy and J. CK. Lee (eds.), *The Routledge Handbook of Schools and Schooling in Asia.* London: Routledge.

Wiersma, W. and Jurs, S.G. (2005). *Research methods in education. An introduction*. Boston: Pearson Education, Inc.

Williams, T.R. (2017). Using a PRISM for Reflecting: Providing Tools for Study Abroad Students to Increase Their Intercultural Competence. Frontiers. *The Interdisciplinary Journal of Study Abroad*, 29(2), pp.18-34.

Wiles, R. (2013). *What are qualitative research ethics?* London: Bloomsbury.

Winchester, T.M. and Winchester, M.K. (2014). A longitudinal investigation of the impact of faculty reflective practices on pupils' evaluations of teaching. *British Journal of Educational Technology*, 45(1), pp.112-124.

Wing, C., Simon, K., and Bello-Gomez, R.A. (2018). Designing difference in difference studies: best practices for public health policy research. *Annual Review of Public Health*, 39, pp.453-469.

Wium, A.M. and Louw, B. (2018). Mixed-methods research: A tutorial for speech-language therapists and audiologists in South Africa. *South African Journal of Communication Disorders*, 65(1), pp.1-13.

Wood, D.K. and Frank, A.R. (2000). Using Memory-Enhancing Strategies to Learn Multiplication Facts. *Teaching Exceptional Children*, 32(5), pp.78-82.

Wong, T.T.Y. and Ho, C.S.H. (2017). Component processes in arithmetic word-problem solving and their correlates. *Journal of Educational Psychology*, 109(4), pp.520-531.

World Bank Group (2018). *The changing nature of work*. World development report (2019). Washington, DC: World Bank.

World Bank (2008). *The road not travelled: education reform in the Middle East and North Africa.* Washington, DC: World Bank.

Worthen, J.B. and Hunt, R.R. (2011*). Mnemonology: Mnemonics for the 21st century*. New York: Taylor and Francis.

Wu, H. H. (2018). The content knowledge mathematics teachers need. In Y. Li, W. Lewis, J. Madden (eds.)*, Mathematics matters in education. Advances in STEM education*, pp.43-91. Springer.

Xie, M. and Sharif, R.T.S. (2014). The Relationship between Teachers' Knowledge, Attitude and Belief with the Implementation of Inquiry-Based Learning in Zhengzhou, China. *International Journal of Learning, Teaching and Educational Research*, 8(1), pp.149-161.

Xin, Y.P., Zhang, D., Park, J.Y., Tom, K., Whipple, A., and Si, L. (2011). A comparison of two mathematics problem-solving strategies: Facilitate algebra-readiness. *The Journal of Educational Research*, 104(6), pp.381-395.

Xu, L. (2012). The role of teachers' beliefs in the language teaching-learning process. *Theory and Practice in Language Studies*, 2(4), pp.1397-1402.

Yan, E.M., Evans, I.M. and Harvey, S.T. (2011). Observing emotional interactions between teachers and pupils in elementary school classrooms. *Journal of Research in Childhood Education*, 25(1), pp.82-97.

Yeh, Y.C. (2006). The interactive effects of personal traits and guided practices on preservice teachers' changes in personal teaching efficacy. *British Journal of Educational Technology*, 37(4), pp.513-526.

Yeo, K.K.J. (2008). Teaching Area and Perimeter Mathematics-Pedagogical Content Knowledge in Action. In M. R, Brown and K. Maker (eds.). *Proceedings of the 31st Annual Conference of the Mathematics Education Research Group, Australia.*

Yendol-Hoppey, D. and Franco, Y. (2014). In search for signature pedagogy for clinically rich teacher education: A review of articles published in the Journal of Teacher Education and School University Partnerships. *School-University Partnerships Journal*, 7(1), pp.17-34.

Yin, R. (2018). *Case Study Research and Applications: Design and Methods,* (6th edn.). Thousand Oaks, CA: Sage Publications.

Yoon, K.S., Duncan, T., Lee, S.W.-Y., Scarloss, B., and Shapley, K. (2007). *Reviewing the evidence on how teacher professional development affects student achievement* (Issues and Answers Report, REL 2007-No. 033). Washington, DC: U.S. Department of Education.

York-Barr, J., Sommers, W.A., Ghere, G.S. and Montie, J. (2006). *Reflective practice to improve schools: An action guide for educators*. Thousand Oaks, CA: Corwin Press.

Zahid, M. and Khanam, A. (2019). Effect of Reflective Teaching Practices on the Performance of Prospective Teachers. *Turkish Online Journal of Educational Technology*, 18(1), pp.32-43.

Unal, Z. and Unal, A. (2012). The impact of years of teaching experience on the classroom management approaches of elementary school teachers. *International Journal of Instruction*, 5(2), pp.41-60.

Zeichner, K. and Liston, D. (1996). *Reflective Teaching: An Introduction*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Zhang, Q. and Stephens, M. (2013). Utilising a construct of teacher capacity to examine national curriculum reform in mathematics. *Mathematics Education Research Journal*, 25(4), pp.481-502.

Zhou, X. and Hall, J.N. (2018). Mixed methods papers in first-person and third person: Writing voices in dialogue. *Journal of Mixed Methods Research*, 12(3), pp.344-357.

Zhukova, O. (2018). Novice Teachers Concerns, Early Professional Experiences and Development: Implications for Theory and Practice. *Discourse and Communication for Sustainable Education*, 9(1), pp.100-114.

Zulfikar, T. and Mujiburrahman (2018). Understanding own teaching: becoming reflective teachers through reflective journals. *Reflective Practice*, 19(1), pp.1-13.

Zwozdiak-Myers, P. (2012). *The teacher's reflective practice handbook: becoming an extended professional through capturing evidence-informed practice*. Florence, KY: Routledge.

Yenilmez, K., and Yasa, E. (2007). An investigation on problem solving skills of primary school students, E-*Journal of New World Sciences Academy*, 2(4), pp.272-287.

APPENDICES

APPENDIX 1 - Table 5.1: Outline of the Data Source, Methods and Analysis as Linked to the Research Questions

Research Question (RQ)	Purpose	Participants and Sample Size	Data Source/ Methods	Data Analysis
RQ1 To what extent do the MKT sub-domains and MKT self-efficacy beliefs of primary teachers develop after engaging in RP?	The purpose was to gather the teachers' MKT sub-domains and MKT self-efficacy beliefs after the RP intervention.	58 primary mathematics teachers participants Experimental group (n= 17) Control group (n= 41)	Pre-post Survey Questionnaire Reflective Journal Interviews Field notes MKT pre-post-tests	**Quantitative and Qualitative** • Descriptive statistical analysis • t-test • Difference in Differences estimate • Thematic analysis
RQ2. Is there a statistically significant difference between the MKT sub-domain scores of the intervention and control group after engaging in RP?	The purpose was to capture and consider the difference in MKT sub-domain scores of the intervention and control group participants after the RP intervention.	Control group (n=41) Experimental group (n=17)	MKT pre-post-tests	**Quantitative** t-test

RQ3. To what extent does the MTSE level of primary teachers change after engaging in RP?	The purpose is to gather the teachers' MTSE mathematics teaching self-efficacy beliefs before and after the RP intervention.	Control group (n=41) Experimental group (n=17)	Pre- Post-Survey Questionnaire Reflective Journal Interviews Field notes	**Quantitative and Qualitative** • Descriptive statistical analysis • Difference in Differences estimate • Thematic analysis
RQ4. Is there a statistically significant difference between the MKT self-efficacy beliefs of the intervention and control group after engaging in RP?	The purpose is to capture and consider the difference in the MKT self-efficacy beliefs of the intervention and control group participants after the RP intervention.	Control group (n=41) Experimental group (n=17)	Pre-Post Survey Questionnaire	**Quantitative** t-test
RQ5 Is there a statistically significant difference between the MTSE of the intervention group and the control group after engaging in RP?	The purpose is to capture and consider the difference in MTSE of the intervention and control group participants after the RP intervention.	Control group (n=41) Experimental group (n=17)	Pre-Post Survey Questionnaire	**Quantitative** t-test

Main RQ: To what extent does participating in reflective practice change the MKT sub-domains, MKT self-efficacy and MTSE beliefs of primary teachers?	The purpose is to determine the effect of RP intervention on the mathematical knowledge and mathematics teaching self-efficacy of primary teachers.	All the data gathering methods mentioned above	Integrating the above qualitative and quantitative analyses

APPENDIX 2- Post-intervention Interview Schedule

Research Title: The development of teachers' mathematical knowledge for teaching through RP: A case study of primary schools in Seychelles.

Time: **Date and location of Interview:**

Interviewer: **Mobile digits of Interviewee:**

Length: **Number of years teaching:**

Interview Procedure

You are participating in a research study exploring the effect of RP on the mathematical knowledge for teaching of primary teachers. The purpose of the interview is to obtain your views and experiences pertaining to your reflective sessions. If you agree to be interviewed, you will be asked to respond to some questions and the interviewer will audio-record your responses. Your response to the interview will remain confidential, and your identity will remain anonymous.

	1.	Tell me about your job. What makes you stay in the profession?
Opening	2.	Can you please talk about your learning and teaching experiences when using the PIES mnemonic strategy to teach mathematical word problems? Probes: What were the benefits? Probes: How did it support your teaching?
Introductory Transition	3.	Please tell me the things you learnt, if any, when using the PIES mnemonic strategy to teach mathematical word problems?
	4.	What for you were the benefits, if any, of the process of reflective writing and keeping a reflective journal.
Have a visual aid	5.	How much change, if any, has RP brought to your

with the 5 MKT sub-domains, and use them as prompts		mathematical knowledge for teaching? Probes: Which specific Knowledge?
Key Questions	6.	How much change, if any, do you think reflecting on the PIES mnemonic strategy has brought to your teaching of mathematics word problems? Probes: What are those changes?
	7.	Are there specific mathematical teaching skills which you have now, but you did not have before those reflective sessions?
	8.	How much change, if any, has RP brought to your confidence in teaching mathematics?
	9.	How has writing a reflective journal helped you as a teacher?
Ending Questions	10.	Is there anything else that we missed you would like to add to the interview which you feel is important to the research, but you have not had the opportunity to say?

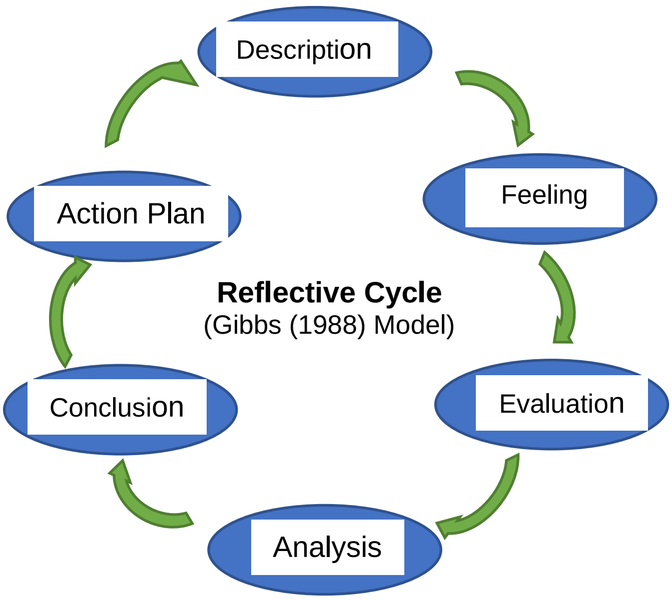
Thank you for taking part in this interview. If you have questions pertaining to this interview, contact me through the phone number +2482611358.

Associated field notes

APPENDIX 3 - Reflective Journal Prompt for Teachers

The purpose of this Journal Prompt is to examine and describe your experience of the process of your reflective practice.

Your reflective writing should include a looking back at your teaching and learning situations, and what you have



Please write in your reflective journal at least on a weekly basis. You can write your experiences onsite (during class), as well as offsite (after class). Write your self-reflection based on these questions below each time you reflect on your classroom experience.

Journal #…………… Class: Date:

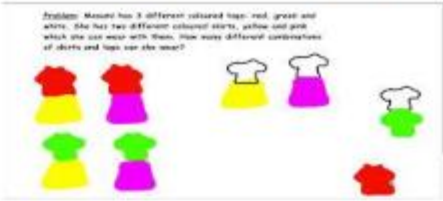
1. Description **(Reflection in and on action)** What happened?	**Provide a description of what you are reflecting on (e.g. event or experience)** Recollect a critical incident, event, or experience that occurred this week during your mathematics teaching. What happened? Who else was there? What did you plan to do in that lesson? Describe the activities that led up to that experience.
2. Feelings What were you feeling?	What did you feel during the experience? What did you do during the experience? How did you feel about your lesson?
3. Evaluation What was good or bad?	What did work during the experience? What did not work during the experience? What was bad about the experience?
4. Analysis What sense can you make of it?	What went well and what did not go so well? What are the causes of the things that went badly?
5. Conclusion What else could you have done?	What have you learnt from the experience? Is there anything else you could have done to improve on the positive outcome? Is there anything else you could have done to improve on the negative outcome?
6. Action Plan If the event arises again, what would you do?	What should I learn to do to improve on a similar event the next time? Should I do it differently or should I do it the same?

APPENDIX 4 - Pies Card for Pupils

PIES Card for Students (Card was used as a way to motivate the students)

PIES and Word Problems!

P…… Draw the Picture



I……. Pull out the Information

E……Write down the Equation,

S…... Write the solution

APPENDIX 5 - Independent Samples T-Test on the Pre-intervention MKT Test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Group1	17	45.5294	15.08773	3.65931
	Group2	41	47.5610	14.32838	2.23772

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	.513	.477	-.484	56	.630	-2.03156	4.19703	-10.43923	6.37610
	Equal variances not assumed			-.474	28.604	.639	-2.03156	4.28928	-10.80941	6.74629

APPENDIX 6 - Ethical Approval Form

STAFFORDSHIRE UNIVERSITY

Life Sciences and Education

ETHICAL APPROVAL FEEDBACK

Researcher name:	Bryan George Moumou
Title of Study:	The development of primary teachers' mathematical knowledge for teaching through reflective practice: A case study of primary schools in the Seychelles.
Status of approval:	Approved

Thank you for addressing the committee's comments. Your research proposal has now been approved by the Ethics Panel and you may commence the implementation phase of your study. You should note that any divergence from the approved procedures and research method will invalidate any insurance and liability cover from the University. You should, therefore, notify the Panel of any significant divergence from this approved proposal.

You should arrange to meet with your supervisor for support during the process of completing your study and writing your dissertation.

When your study is complete, please send the ethics committee an end of study report. A template can be found on the ethics BlackBoard site.

R. Naemi

Signed: Dr Roozbeh Naemi **Date: 26.10.2018**

Ethics Coordinator
School of Life Sciences and Education

APPENDIX 7- Ministry of Education Research Permission Letter

MINISTRY OF EDUCATION
Early Childhood, Primary and Secondary Education Department
Mont Fleuri, P.O. Box 48, Victoria, Mahé, Republic of Seychelles
Tel: 4283011 Fax: 4224859 E-mail: mdelcy@eduhq.edu.sc

Office of the Principal Secretary

Date: 2nd February, 2015

Mr Bryan Moumou
University of Seychelles
Anse Royale Campus

Dear Mr Moumou,

Subject: Request for Permission to Conduct Research in Schools

Reference is made to your letter dated 28th January, 2015 with regards to the above mentioned subject.

Please be informed that permission has been granted for you to carry out your research on Mathematics education in primary schools.

Good luck with the research and all the very best in your course.

Yours sincerely

Merida Delcy (Mrs)
Principal Secretary

APPENDIX 8 - Permission Letter to the Ministry of Education

Mrs Merina Delcy
Principal Secretary of Education
Mont Fleuri
PO Box 48
Mahe
Seychelles

Mr Bryan Moumou
PHD Student at Staffordshire University
C/o University of Seychelles
Anse Royale Campus
Tel: 02482611358
Email: brymou@outlook.com
Mahe
Seychelles

Date: 10th January 2015

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SCHOOLS

Dear Mrs Delcy,

My name is Bryan Moumou, working at the University of Seychelles and a part-time mathematics lecturer at the Seychelles Institute of Teacher Education (SITE), as well at the Adult Learning and Distance Education Centre (ALDEC). I am a PhD student at Staffordshire University in the United Kingdom. For my doctoral thesis, I wish to carry out research in mathematics education in primary schools in Seychelles. The research involves the improvement of mathematics teaching in primary schools in Seychelles by improving the teachers' mathematical knowledge for teaching and their self-efficacy beliefs. The research will be conducted under the supervision of my supervisors from Staffordshire University.

Research Relevance

The research has direct benefits to primary school pupils and teachers in Seychelles. It should bring a major contribution in the continuous effort to improve mathematics performance in the primary schools, and the results will provide a valuable basis for improving mathematics education and planning future research.

Confidentiality

Throughout the research process, there will be the anonymity and privacy of all parties participating in the research through the use of pseudonyms and removal of identifiers.

I am, therefore seeking your consent to carry out the research in the primary schools, as well as getting access to relevant mathematics performance data stored on schools and on intended participants of the study. The targeted populations will be teachers and their data from primary one (P1) to primary six (P6).

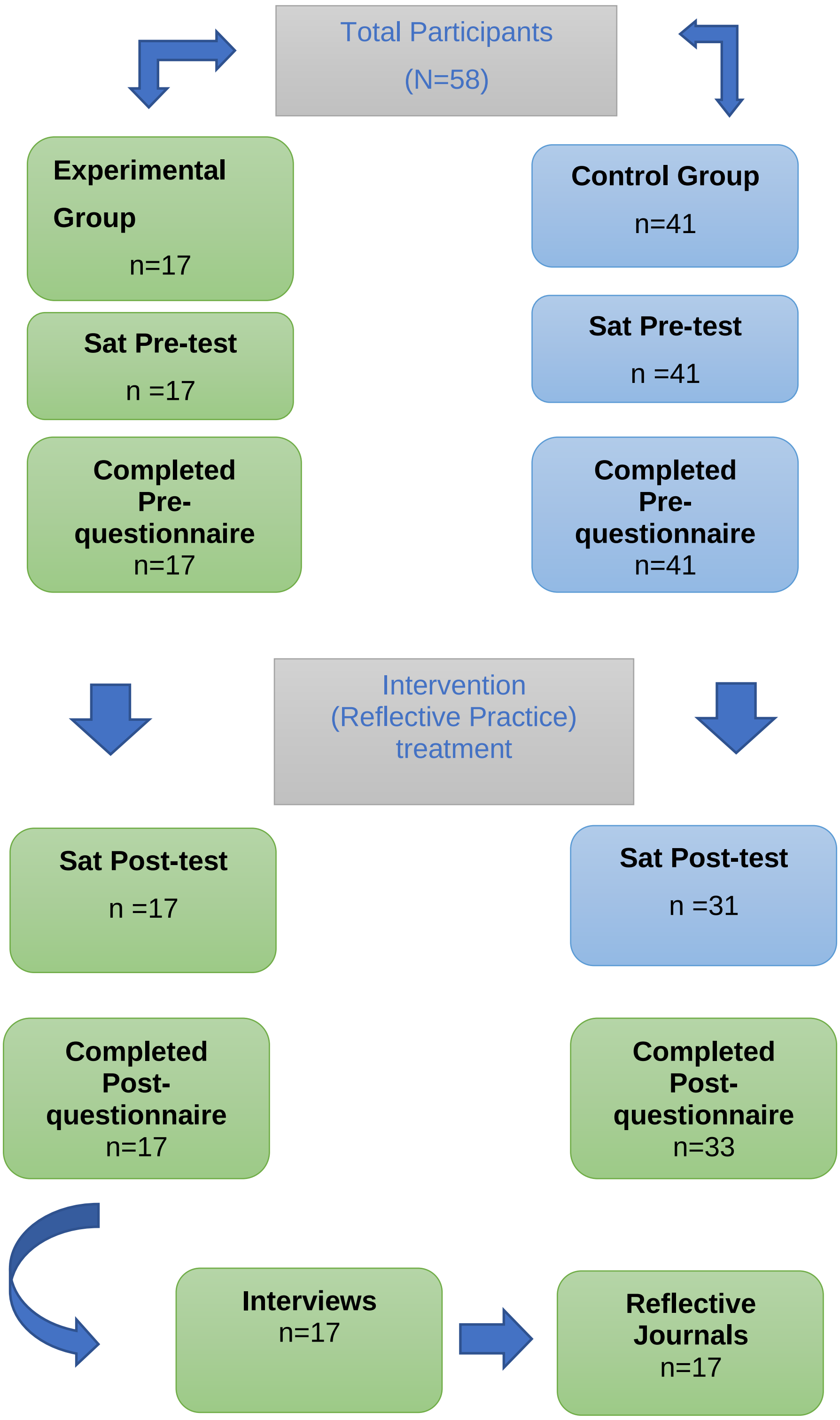
Feedback

Upon the completion of the study, I will provide the Ministry of Education with a full copy of the research report.

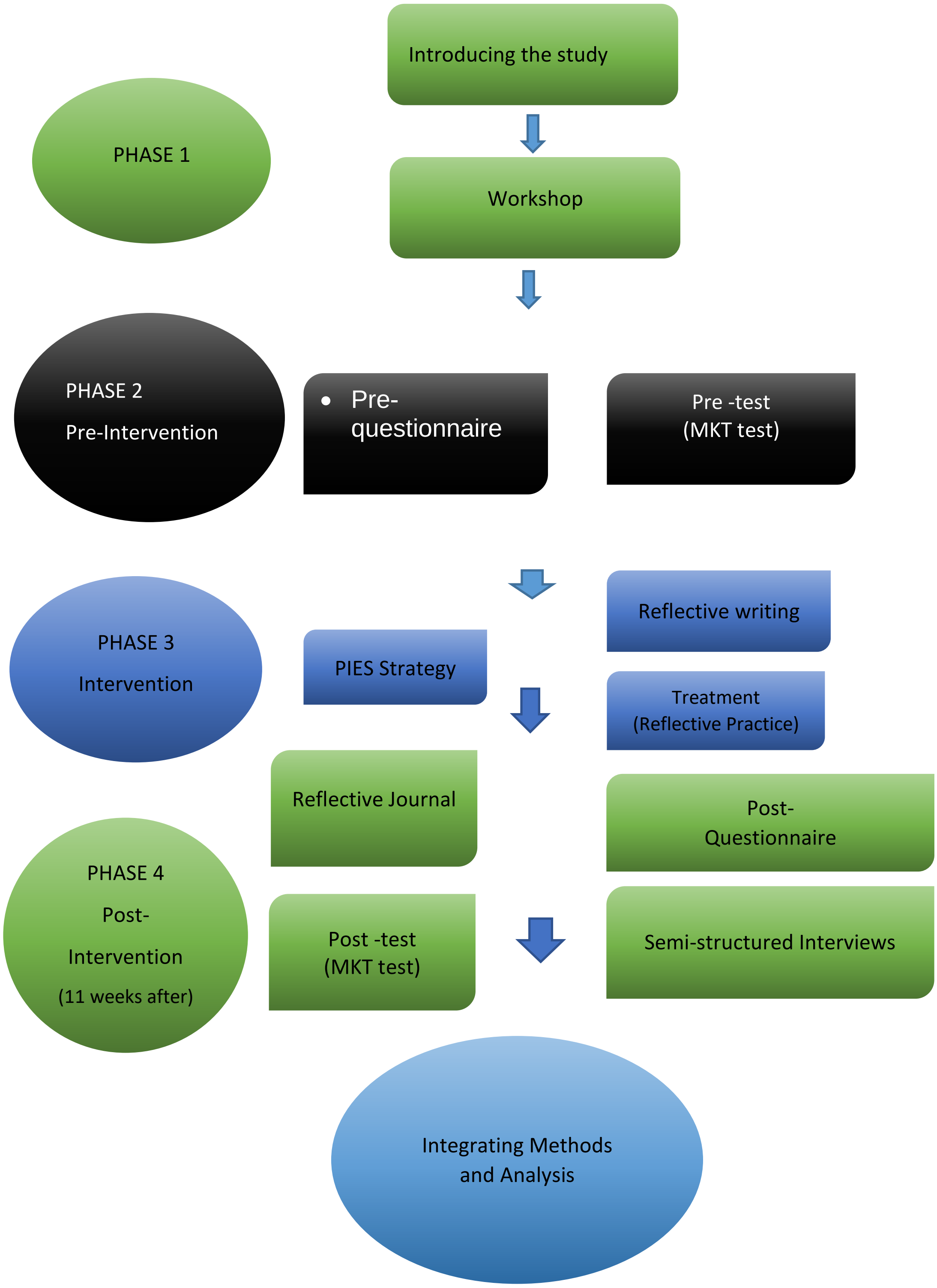
Thank you very much for your time and consideration.

Yours sincerely,
Bryan Moumou (Mr.)

APPENDIX 9 - Figure 5.1: Samples of Participants in the Intervention



APPENDIX 10 - Figure 5.2: Overview of Study Phases



APPENDIX 11- Pre-intervention Teacher Questionnaire

STAFFORDSHIRE UNIVERSITY

ID	

Dear teachers,

I am a PhD student currently studying at Staffordshire University (UK) under the supervision of Dr. Gillian Forrester and Dr. Claire Kinsella. My PhD is investigating the development of primary teachers' mathematical knowledge for teaching (MKT) through RP using an intervention programme. The purpose of this research study is to gain insight into the effects of RP on the MKT and mathematics self-efficacy of primary teachers. You are being asked to participate in this study because you are a primary school teacher in Seychelles, and your contributions and views on this issue are very important. Therefore, I would be very grateful if you agree to take part by completing this questionnaire. Participating in the research will not cause any personal risks or disadvantages, as the researcher will protect your identity and confidentiality. If you decide to take part, you will be asked to sign the attached consent form to make sure that you fully understand what you are agreeing to. The research has been approved by the Ethics Committee at Staffordshire University, and I have been granted permission by the Ministry of Education of Seychelles to collect data in the schools.

If you agree to participate in this study, please sign the attached consent form, and then complete this questionnaire.

Yours sincerely,
Bryan Moumou (Mr.)
Doctoral pupil
School of Life Sciences & Education
Staffordshire University
England
United Kingdom (UK)

Tel: +2482611358
C/O University of Seychelles

Pre-Intervention Questionnaire

Dear Teachers,

This questionnaire seeks your self-perceived knowledge of your mathematical knowledge for teaching, and competence for teaching primary mathematics after the intervention. You are requested to provide honest responses to the questions below. You and your school will not be identified. All information provided will be kept confidential and will be used only for this research purpose. It is important that you answer the questions carefully, so that your answers can accurately reflect your situation. Please place your completed questionnaire in the envelope provided and give it to your mathematics coordinator. Thank you.

Please enter the last 4 digits of your mobile phone in the box on the right. These digits will be used solely by the researcher for the matching up of the questionnaires. ☐

SECTION 1: DEMOGRAPHIC DATA

For all questions, please put a tick **(√)** *in the appropriate box*

Q1. Please indicate your gender.

FEMALE	

MALE	

Q2. What is your age-range?

18-25 yrs.	
26-35 yrs.	
36-45 yrs.	
46-55 yrs.	
More than 55	

Q3. How long have you been teaching?

Less than 1 year	☐
1-5 yrs.	☐
6-10 yrs.	☐
11-15 yrs.	☐
16-20 yrs.	☐
More than 20 yrs.	☐

Q4. Indicate the number of years of mathematics teaching experience by putting a tick in the appropriate box.

Less than 1 year	☐
1-5 yrs.	☐
6-10 yrs.	☐
11-15 yrs.	☐
16-20 yrs.	☐
More than 20 yrs.	☐

Q5. What is your highest level of teaching qualification?

Untrained	☐
Certificated	☐
Diploma	☐
Bachelor's degree	☐

Other *(Please specify)*

……………………………………………………………………………………………………

Q6. What is your highest qualification in mathematics?

None	☐
IGCSE *core* or equivalent	☐
IGCSE *extended* or equivalent	☐
A level	☐

Other *(Please specify)*

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Q7. What is the highest level of teacher training you have completed?

……………………………………………………………………………………………………

Q8. Indicate with a tick the primary levels and cycles you are teaching mathematics this year.

Primary	P1	☐	Cycle	C1	☐
	P2	☐		C2	☐
	P3	☐		C3	☐
	P4	☐			
	P5	☐			
	P6	☐			

SECTION 2: MKT SELF-EFFICACY FOR WORD PROBLEM SOLVING SKILLS

Please answer each question by circling the appropriate number that matches your response to the right of each statement.

1=Disagree Strongly 2=Disagree 3= Slightly Disagree 4=Slightly Agree 5= Agree 6= Agree Strongly							
Q9 **KCS**	I can adapt my teaching to engage pupils' interest when teaching word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q10 **CCK**	I can recognise arithmetical errors when pupils solve mathematical word problems.	**1**	**2**	**3**	**4**	**5**	**6**
Q11	I can evaluate pupils' responses when teaching mathematical word problem	**1**	**2**	**3**	**4**	**5**	**6**

KCS	solving strategies.						
Q12 **KCS**	I can answer pupils' questions when teaching mathematical word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q13 **KC**	I am aware of how word problems are linked to other topics in the primary mathematics curriculum.	**1**	**2**	**3**	**4**	**5**	**6**
Q14 **SCK**	I can address the misconceptions that pupils would have when teaching word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q15 **SCK**	I can provide alternative explanations to pupils when they face difficulties with solving word problems.	**1**	**2**	**3**	**4**	**5**	**6**
Q16 **SCK**	I have a good knowledge of pupils' thinking when teaching word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q17 **KCT**	I can select appropriate mathematical content in order to move the pupils from the known to the unknown.	**1**	**2**	**3**	**4**	**5**	**6**
Q18 **KCT**	The way I teach mathematical word problem solving strategies to pupils is very effective.	**1**	**2**	**3**	**4**	**5**	**6**
Q19 **KCT**	I am satisfied with the way in which I teach pupils to solve mathematical word problems.	**1**	**2**	**3**	**4**	**5**	**6**
Q20 **KCT**	I can use effective teaching strategies to help pupils solve mathematical word problems.	**1**	**2**	**3**	**4**	**5**	**6**
Q21	I am aware of factors that that can affect the problem-solving ability of pupils.	**1**	**2**	**3**	**4**	**5**	**6**
Q 22 **SCK**	I can show pupils a variety of word problem solving techniques.	**1**	**2**	**3**	**4**	**5**	**6**

SECTION 3: REFLECTION EFFICACY

Please answer each question by circling the appropriate number that matches your response to the right of each statement.

1=Disagree Strongly 2=Disagree 3= Slightly Disagree 4=Slightly Agree 5= Agree 6= Agree Strongly							
Q23	Reflecting on my teaching improves my instructions on teaching word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q24	I can effectively reflect during interactions with pupils.	**1**	**2**	**3**	**4**	**5**	**6**
Q25	I can effectively reflect after interactions with pupils.	**1**	**2**	**3**	**4**	**5**	**6**
Q26	I can critically think about the learning experience of my pupils.	**1**	**2**	**3**	**4**	**5**	**6**
Q27	I can reflect on classroom events in order to improve my teaching further.	1	2	3	4	5	6
Q28	I can reflect on mathematical objects (e.g. manipulatives) used with pupils for the teaching of mathematical word problem solving strategies, and their meanings to them.	1	2	3	4	5	6
Q29	When I reflect on my teaching, my knowledge of teaching word problem solving strategies continues to develop.	1	2	3	4	5	6

SECTION 4: TEACHING WORD PROBLEM SOLVING SELF-EFFICACY

Please answer each question by circling the appropriate number that matches your response to the right of each statement.

1=Disagree Strongly 2=Disagree 3=Slightly Disagree 4=Slightly Agree 5=Agree 6= Agree Strongly							
Q30	I can teach mathematics so that pupils can understand better.	1	2	3	4	5	6
Q31	I can provide alternative explanations to pupils when they are confused.	1	2	3	4	5	6
Q32	I can improve the understanding of pupils who are struggling with mathematical word problem solving strategies.	1	2	3	4	5	6

Q33	I find it difficult to teach mathematics for pupils to understand.	1	2	3	4	5	6
Q34	My pedagogical content knowledge (how to explain mathematics to pupils that will make them understand) of primary mathematics needs to be improved.	1	2	3	4	5	6
Q35	I feel I have insufficient knowledge on how to teach word problem solving strategies.	1	2	3	4	5	6
Q36	I have insufficient knowledge of mathematical problem-solving strategies.	1	2	3	4	5	6
Q37	I have appropriate confidence to teach pupils how to solve mathematical word problems.	1	2	3	4	5	6
Q38	I can develop assessment items that will test pupils word problem solving strategies.	1	2	3	4	5	6
Q39	I can monitor and oversee the entire word problem solving process.	1	2	3	4	5	6
Q40	I can identify pupils difficulties when teaching mathematical word problem solving strategies.	1	2	3	4	5	6
Q41	I can explain and justify when solving mathematical word problems.	1	2	3	4	5	6
Q42	I ask pupils to explain their reasoning when providing an answer.	**1**	**2**	**3**	**4**	**5**	**6**
Q43	I am well equipped with mathematics concepts and procedures to teach mathematical word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q44	I am well equipped with mathematics procedures to teach mathematical word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q45	I enjoy teaching mathematics.	**1**	**2**	**3**	**4**	**5**	**6**

SECTION 5

Now that you have taken part in the intervention on reflection practice, I would appreciate if you could answer this last section which seeks your views and effects of the intervention.

OPEN-ENDED QUESTIONS

Q46. What do teachers need to know to teach word problem solving strategies?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Q47. What significant problems are you currently facing with the teaching of mathematical word problem solving strategies to pupils?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Q48. What types of mathematical problem-solving knowledge for teaching do you wish you could have, and what would be their advantages?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

End of Questionnaire

Thank you for taking your invaluable time to complete this questionnaire

APPENDIX 12 - Post-intervention Teacher Questionnaire

STAFFORDSHIRE UNIVERSITY

ID

Dear teachers,

I am a PhD student currently studying at Staffordshire University (UK) under the supervision of Dr Gillian Forrester and Dr. Clare Stanier. My PhD is investigating the development of primary teachers' mathematical knowledge for teaching (MKT) through RP using an intervention programme. The purpose of this research study is to gain insight into the effects of RP on the MKT and mathematics self-efficacy of primary teachers. You are being asked to participate in this study because you are a primary school teacher in Seychelles, and your contributions and views on this issue are very important. Therefore, I would be very grateful if you agree to take part by completing this questionnaire. Participating in the research will not cause any personal risks or disadvantages, as the researcher will protect your identity and confidentiality. If you decide to take part, you will be asked to sign the attached consent form to make sure that you fully understand what you are agreeing to. The research has been approved by the Ethics Committee at Staffordshire University, and I have been granted permission by the Ministry of Education of the Seychelles to collect data in the schools.

If you agree to participate in this study, please sign the attached consent form, and then complete this questionnaire.

Yours sincerely,
Bryan Moumou (Mr.)
Doctoral pupil
School of Life Sciences & Education
Staffordshire University
England
United Kingdom (UK)

Tel: +2482611358
C/O University of Seychelles

Post-Intervention Questionnaire
Dear Teachers,

This questionnaire seeks your self-perceived knowledge of your mathematical knowledge for teaching, and competence for teaching primary mathematics after the intervention. You are requested to provide honest responses to the questions below. You and your school will not be identified. All information provided will be kept confidential and will be used only for this research purpose. It is important that you answer the questions carefully, so that your answers can accurately reflect your situation. Please place your completed questionnaire in the envelope provided and give it to your mathematics coordinator. Thank you.

Please enter the last 4 digits of your mobile phone in the box on the right. These digits will be used solely by the researcher for the matching up of the questionnaires. ☐

SECTION 1: DEMOGRAPHIC DATA

For all questions, please put a tick **(√)** *in the appropriate box*

Q1. Please indicate your gender.

FEMALE		MALE	

Q2. What is your age-range?

18-25 yrs.	
26-35 yrs.	
36-45 yrs.	
46-55 yrs.	
More than 55	

Q3. How long have you been teaching?

Less than 1 year	
1-5 yrs.	
6-10 yrs.	
11-15 yrs.	
16-20 yrs.	
More than 20 yrs.	

Q4. Indicate the number of years of mathematics teaching experience by putting a tick in the appropriate box.

Less than 1 year	
1-5 yrs.	
6-10 yrs.	
11-15 yrs.	
16-20 yrs.	
More than 20 yrs.	

Q5. What is your highest level of teaching qualification?

Untrained	
Certificated	
Diploma	
Bachelor's degree	

Other *(Please specify)*

……
…

Q6. What is your highest mathematics qualification?

None	
IGCSE *core* or equivalent	
IGCSE *extended* or equivalent	
A level	

Other *(Please specify)*

……

……

Q7. What is the highest level of teacher training you have completed?

……………………………………………………………………………………………………

Q8. Indicate with a tick the primary levels and cycles you are teaching mathematics this year.

Primary	P1	☐	Cycle	C1	☐
	P2	☐		C2	☐
	P3	☐		C3	☐
	P4	☐			
	P5	☐			
	P6	☐			

SECTION 2: MKT SELF-EFFICACY FOR WORD PROBLEM SOLVING SKILLS

Please answer each question by circling the appropriate number that matches your response to the right of each statement.

1=Disagree Strongly 2=Disagree 3= Slightly Disagree 4=Slightly Agree 5= Agree 6= Agree Strongly							
Q9 **KCS**	I can adapt my teaching to engage pupils' interest when teaching word problem solving strategies.	1	2	3	4	5	6
Q10 **CCK**	I can recognise arithmetical errors when pupils solve mathematical word problems.	1	2	3	4	5	6
Q11 **KCS**	I can evaluate pupils' responses when teaching word problem solving strategies.	1	2	3	4	5	6
Q12 **KCS**	I can answer pupils' questions when teaching word problem solving strategies.	1	2	3	4	5	6
Q13 **KC**	I am aware of how word problems are linked to other topics in the primary mathematics curriculum.	1	2	3	4	5	6
Q14 **SCK**	I can address the misconceptions that pupils would have when teaching word problem solving strategies.	1	2	3	4	5	6
Q15 **SCK**	I can provide alternative explanations to pupils when they face difficulties with solving word problems.	1	2	3	4	5	6
Q16 **SCK**	I have a good knowledge of pupils' thinking.	1	2	3	4	5	6

Q17 KCT	I can select appropriate mathematical content in order to move the pupils from the known to the unknown.	1	2	3	4	5	6
Q18 KCT	The way I teach mathematical word problem solving to pupils is very effective.	1	2	3	4	5	6
Q19 KCT	I am satisfied with the way in which I teach pupils to solve mathematical word problems.	1	2	3	4	5	6
Q20 KCT	I can use effective teaching strategies to help pupil solve mathematical word problems.	1	2	3	4	5	6
Q21	I am aware of factors that that can affect the problem-solving ability of pupils.	1	2	3	4	5	6
Q 22 SCK	I can show pupils a variety of word problem solving techniques.	1	2	3	4	5	6

SECTION 3: REFLECTION EFFICACY

Please answer each question by circling the appropriate number that matches your response to the right of each statement.

1=Disagree Strongly 2=Disagree 3= Slightly Disagree 4=Slightly Agree 5= Agree 6= Agree Strongly							
Q23	Reflecting on my teaching improves my instructions on teaching word problem solving strategies.	**1**	**2**	**3**	**4**	**5**	**6**
Q24	I can effectively reflect during interactions with pupils.	**1**	**2**	**3**	**4**	**5**	**6**
Q25	I can effectively reflect after interactions with pupils.	**1**	**2**	**3**	**4**	**5**	**6**
Q26	I can critically think about the learning experience of my pupils.	**1**	**2**	**3**	**4**	**5**	**6**
Q27	I can reflect on classroom events in order to improve my teaching further.	**1**	**2**	**3**	**4**	**5**	**6**
Q28	I can reflect on mathematical objects (e.g. manipulatives) used with pupils for the teaching of mathematical word problem solving strategies, and their meanings to them.	**1**	**2**	**3**	**4**	**5**	**6**
Q29	When I reflect on my teaching, my knowledge of teaching word problem solving continues to develop.	**1**	**2**	**3**	**4**	**5**	**6**

SECTION 4: Teaching word problem solving self-efficacy

Please answer each question by circling the appropriate number that matches your response to the right of each statement.

1=Disagree Strongly 2=Disagree 3=Slightly Disagree 4=Slightly Agree 5=Agree 6= Agree Strongly							
Q30	I can teach mathematics so that pupils can understand better.	1	2	3	4	5	6
Q31	I can provide alternative explanations to pupils when they are confused.	1	2	3	4	5	6
Q32	I can improve the understanding of pupils who are struggling with mathematical word problem solving.	1	2	3	4	5	6
Q33	I find it difficult to teach mathematics for pupils to understand.	1	2	3	4	5	6
Q34	My pedagogical content knowledge (how to explain mathematics to pupils that will make them understand) of primary mathematics needs to be improved.	1	2	3	4	5	6
Q35	I feel I have insufficient knowledge on how to teach word problem solving strategies.	1	2	3	4	5	6
Q36	I have insufficient knowledge of mathematical problem-solving strategies	1	2	3	4	5	6
Q37	I have appropriate confidence to teach pupils how to solve mathematical word problems.	1	2	3	4	5	6
Q38	I can develop assessment items that will test pupils word problems solving skills.	1	2	3	4	5	6
Q39	I can monitor and oversee the entire word problems solving process.	1	2	3	4	5	6
Q40	I can identify pupils difficulties when teaching mathematical word problem solving strategies	1	2	3	4	5	6
Q41	I can explain and justify when solving mathematical word problems.	1	2	3	4	5	6
Q42	I ask pupils to explain their reasoning when providing an answer.	1	2	3	4	5	6
Q43	I am well equipped with mathematics concepts and procedures to teach mathematical word problem solving.	1	2	3	4	5	6
Q44	I am well equipped with mathematics procedures	1	2	3	4	5	6

	to teach mathematical word problem solving strategies.						
Q45	I enjoy teaching mathematics.	**1**	**2**	**3**	**4**	**5**	**6**

SECTION 5

Now that you have taken part in the intervention on reflection practice, I would appreciate if you could answer this last section which seeks your views and effects of the intervention.

OPEN-ENDED QUESTIONS

Q46. What do you feel are the benefits if any of keeping a reflective journal?

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Q47. List two things you found useful about this intervention.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Q48. List two things you did not like about this intervention.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Q49. Has carrying out RP changed the way you teach mathematics?

YES/NO, please explain:

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Q50. Has RP affected your self-confidence?

YES/NO, please provide an explanation for your response

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Q51. Did the journal writing help you to address specific challenges in your teaching?

YES/NO, please provide an explanation for your response.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

End of Questionnaire

APPENDIX 13 - Table 5.4: The Thematic Data Analysis Process and Activities (Braun and Clarke, 2013)

Phase	Thematic Analysis	Description	Means of Establishing Rigor
1	Textual data preparation and compilation	Transcription of interviews. Typing Reflective Journal, interviews, and field notes in Microsoft Word.	The researcher was the sole person handling the data.
2	Reading and familiarisation with data	Applied literal, interpretive and reflexive reading level when reading the transcript, journals and field notes. Read and re-read the transcript.	The researcher spent a lot of time with the data in the field and kept records of them during and after data collection.
3	Generate initial codes across entire dataset (open coding) and *a priori* codes	Make coding of the data using themes involving open coding, axial coding and selective coding. Coded paragraphs. Used code from conceptual framework.	Use of a code book.
4	Search for themes	Search for themes. Converting themes to categories and refinement.	Use of thematic map.
5	Review themes using a thematic map	Check theme connectivity with entire data set using a thematic map.	Apply referential integrity by referring to raw data.
6	Define and name themes	Finalise on the organisation and naming of each of them.	Documentation of theme names.
7	Write up	Selection of compelling extracts for reporting in relation to the report question.	Sufficient description of analysis process. Member checks. Thick descriptions.
8	Make generalisations from themes in the form of theory		

APPENDIX 14 - Table 5.5: Deductive (*Priori)* Coding

Code	Definitions (Tasks of Teaching)
Common Content Knowledge (CCK)	Participants referring to knowledge of how to correctly perform a particular mathematical calculation.
Specialised Content Knowledge (SCK)	Participants referring to special knowledge to teach and unpack concepts for pupils, or type of pupil errors and patterns.
Knowledge of Content and Teaching (KCT)	Participants referring to knowledge about mathematics and teaching.
Knowledge of Content Student (KCS)	Participants referring to knowledge about mathematics and pupils (e.g. Predicting and interpreting pupils' thinking).
Knowledge of Curriculum	Participants referring to knowledge of curriculum or resources for teaching.

APPENDIX 15- Information Sheet for Teachers

Researcher: Bryan Moumou, School of Life Sciences and Education, Staffordshire University, United Kingdom.

Research Study

An investigation into the development of primary teachers' mathematical knowledge for teaching and mathematics self-efficacy through reflective practice (RP).

I am a Ph.D. student currently studying at Staffordshire University (UK) under the supervision of Dr. Gillian Forrester and Dr. Clare Kinsella. My Ph.D. research is an investigation of the development of primary teachers' mathematics knowledge for teaching (MKT) through RP. You are invited to take part in this study and below is some information to help you decide whether or not to take part. Please take the time to read the information, and please ask me if there is anything you do not understand.

The purpose of this research is to gain insight into the effect of RP of primary teachers on their teaching practice.

You have been chosen to participate in this study because you are a primary school teacher in Seychelles, and your contributions and views on this issue are very important. Therefore, I would be very grateful if you would agree to take part.

The data collection will be conducted in three phases and will last for three months. In the first phase, you will be asked to fill in a questionnaire about your mathematical knowledge for teaching. It is anticipated that the questionnaire will take about forty-five minutes to complete. You could then be chosen for one of your mathematics classes to be observed by the researcher. Phase two of the research will start by asking you to complete a mathematical knowledge for teaching test which should last about forty -five minutes. ***Then,*** **you will be asked to teach pupils mathematics word problem strategies using the PIES mnemonic strategy which will be introduced to you by the researcher. PIES is a four-step process which can be used to help pupils solve mathematical word problems. The acronym P represents PICTURE, I represents INFORMATION, E represents EQUATION, and S represents SOLVE. The PIES strategy has successfully been used by Heater et al., (2012) in both science and mathematics teaching.** You could then be asked to reflect on your practices, as well as keeping a reflective journal. The journal will be in the form of a physical notebook whereby you record reflections on your teaching. The journal entries will be collected from you after the first three weeks of the start of the intervention, and at the end of the intervention. At the end of the three months you will be asked to complete another mathematical knowledge for teaching test, and complete a questionnaire. Lastly, you could then be chosen for a face-to-face interview with the researcher. It is anticipated that the interview will take approximately forty-five minutes to complete and this will be audio-recorded for the purpose of this study. You will be heard only by the researcher.

Participating in the research will not cause any personal risks or disadvantages, as the researcher will protect your identity. Your identity and that of your school will remain confidential. None of the information you provide will be linked to you in the final report, or any published academic writing such as conference papers and journals. Pseudonyms will be used in order to ensure anonymity and all data such as transcripts of the interviews will be kept securely and will be destroyed after ten years in accordance with the University procedures. Research data will be stored on the researcher's PC in password-protected files and will be backed up to my personal home PC, which will also be password protected. Manual data files will be stored in locked cabinets in a secure location. If you decide to take part, you will be asked to sign the attached consent form to make sure that you fully understand what you are agreeing to. The research has been approved by the appropriate Ethics Committee at Staffordshire University.

There are no remunerations and personal benefits for the participants in this study. However, you will be contributing to an important study as the knowledge gained as a result of the research will be made available to improve practice by providing schools in Seychelles with a model for the pedagogical development of primary mathematics teachers. It will also contribute to knowledge by informing the MKT literature and teacher training institutions how RP impact on MKT and mathematics self-efficacy.

Your participation in this research is entirely voluntary. You have the right to withdraw from the study at any time by informing me verbally or in writing and you do not have to give a reason for doing so.

There is a minute possibility that participation in this study may cause emotional distress or anxiety for some people and if you are anxious then please contact Ms. Odile Octave (Director General of Schools) on telephone: 4283130.

This research is being undertaken for the purpose of completing a PhD in Education at Staffordshire University, UK. If you have any queries or questions related to this research, please contact me on 2611358, or by email at (brymou@outlook.com or m027366e@student.staffs.ac.uk). If you have any concerns about this research, please feel free to contact my principal supervisor, Dr. Gillian Forrester. Her email address is: gillian.forrester@staffs.ac.uk

If you agree to participate in this study, please sign and return one attached consent form by ………………….

Please retain this sheet of paper for your records. The signed consent form should be returned to me, and it will be stored securely at home in a locked cabinet.

General Data Protection Regulation 2016 (GDPR).
Your data will be processed in accordance with the General Data Protection Regulation 2016 (GDPR). The data controller for this project will be Staffordshire University. The University will process your personal data for the purpose of the research outlined in this information sheet. The legal basis for processing your personal data for research purposes under GDPR is a ‘task in the public interest’. You can provide your consent for the use of your personal data in this study by completing the consent form that has been provided to you. You have the right to access information held about you. Your right of access can be exercised in accordance with the GDPR. You also have other rights including rights of correction, erasure, objection, and data portability. Questions, comments and requests about your personal data can also be sent to the Staffordshire University Data Protection Officer. If you wish to lodge a complaint with the Information Commissioner’s Office, please visit www.ico.org.uk.

Thank you for taking the time to read this information sheet and considering this request.

Bryan Moumou (Mr.) Signed:

APPENDIX 16 - Consent Form

CONSENT TO PARTICIPATE IN RESEARCH (PRIMARY TEACHERS)

Researcher: Bryan Moumou, School of Life Sciences & Education, Staffordshire University, United Kingdom.

Read each of the following points carefully before acknowledging your participation in the research. Tick appropriately each box to indicate your agreement with each statement.

1. I confirm that I have read and understand the Participant Information Sheet for this Research.

YES	NO

2. I understand the aim and purpose of the research project, and I agree to take part in it.

YES	NO

3. I consent to the digital recording of the interview.

YES	NO

4. I consent to the keeping of a reflective diary.

YES	NO

5. I consent to the sitting of two short tests.

YES	NO

6. I understand that the research will be carried out as described in the information sheet.

YES	NO

7. I understand that my participation in this research is voluntary, and that if I change my mind, I can withdraw at any time up to the point at which data has become aggregated for analysis purposes, without prejudice and without giving a reason.

YES	NO

8. By participating in the research, I understand that confidentiality will be maintained throughout, that I will not be identified in the final report, any other academic writing and conference presentations, and that quotations can be used in the report as long as they are anonymised.

YES	NO

9. I will commit myself in keeping the school's and pupils' participation in this research confidential.

YES	NO

10. I have read the information sheet regarding the General Data Protection Regulation 2016 (GDPR) and I give my consent for my data to be processed in accordance with the GDPR.

YES	NO

Participant's Name:	Signature:	Date:

Researcher:
Bryan Moumou
University of Seychelles
Tel: (248) 2611358
Email: brymou@outlook.com

Principal supervisor:
Dr. Gillian Forrester
Staffordshire University
School of Life Sciences & Education
Email: gillian.forrester@staffs.ac.uk

APPENDIX 17 - Teachers' MKT Test (Pre-test)

TEACHERS' MKT TEST (Pre-test)

Date:

Please enter the last 4 digits of your mobile phone in the box on the right. These digits will be used solely by the researcher for the matching up of the tests.

SECTION A [multiple-choice]

Instructions: Please answer all questions. Read all the answer choices and circle the best answers for each question. At the end of each question give a brief reasoning behind you answer.

1. The marked price of shirts in a store is Rs30. During one week, the store sells m shirts at the marked price and n shirts discounted 10% of the marked price. Which of the following is an expression of the store revenue from shirts sold during that week?
   a) 30m + 30n
   b) 30m + 27n
   c) 30(m + 1n)
   d) 27m + 30n
   e) 27m + 27n

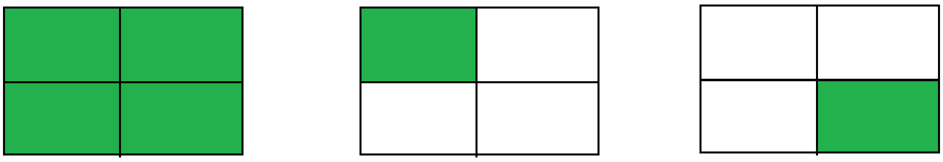
Brief reasoning:

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

2. When teaching fractions, a teacher chooses to represent a whole by these 3 rectangles below.



What fraction of the whole is that teacher illustrating?

a) 3 wholes
b) 5/12
c) 2/4
d) 3/12

Brief reasoning:

…………………………………………………………………………………………........

……………………………………………………………………………….……………

……………………………………………………………………….……………………

---

3. Mrs Bick gave her class some fraction operations to do as homework. One pupil produced the results below. What problem is it that the pupil is having here?

   1/2 x 1/6 = 1/12   2/3 x 2/3 = 4/3   2/7 x 7/8 = 14/56   3/8 x 3/8= 9/8

   a. The pupil does not know how to multiply some numbers correctly.
   b. The pupil made mistakes.
   c. The pupil has not understood multiplication algorithm for fractions.
   d. The pupil does not understand the concept of fractions.

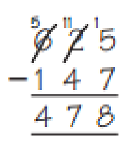
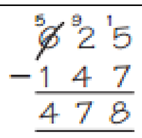
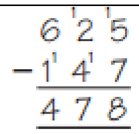
Brief reasoning:

…………………………………………………………………………………………........

……………………………………………………………………………….……………

……………………………………………………………………….……………………

4. Which algorithm of subtraction would you encourage your pupils to use?

A	**B**	**C**
		

   a. Algorithm A because it is easier for pupils.
   b. None of the above

c. Algorithm B because it is easier for pupils.
d. Any one of the three algorithms as long as they understand
e. Algorithm C because it is easier for pupils.

Brief reasoning:

…………………………………………………………………………………………........

…………………………………………………………………………………….……………

…………………………………………………………………………….…………………………

---

5. **Problem 1:** A bag of 12 socks was emptied on the floor, and two children volunteered to count them, and it was agreed that there were 12 socks. The question posed to the class was: When the socks were put back together in pairs, how many pairs of socks would that be?
   Problem 2: Six friends went out for a Chinese meal together. How many chopsticks would they need for them to have a pair each? (*Adapted from Mike Askew: Transforming Primary Mathematics*)

   Why is it that some pupils would not see the mathematical connection between these two problems?

   a. The mathematical connection is not obvious to children.
   b. Socks are socks and chopsticks are chopsticks.
   c. There is the natural drive to look for the correct answers, rather than understanding the underlying mathematics.
   d. Children do not have a mindful approach to mathematics.

Brief reasoning:

…………………………………………………………………………………………........

…………………………………………………………………………………….……………….…

…………………………………………………………………………….…………………………

---

6. The operation below in this question involves teaching pupils decomposition with manipulatives to solve a story problem using subtraction of 3-digit numerals.

$$\begin{array}{r} 862 \\ -374 \\ \hline 488 \end{array}$$

Which incorrect instruction should not be in the list below?

   a. Tell stories to match the numbers in the problems.
   b. Introduce the regrouping and renaming subtraction model.
   c. Introduce subtraction concepts.
   d. Plan for a small group re-teach.
   e. Ask pupils to accurately model several problems.

Brief reasoning:

………………………………………………………………………………………………........

…………………………………………………………………………………….………………

7. When developing the traditional multiplication algorithm with children (see example below), they should be encouraged to think of how to shorten the algorithm. This can happen by:

H	T	U	H	T	U
	2	4		2	4
	X	3		X	3
	1	2		7	2
	6	0			
	7	2			

   a. Only one multiplier is recorded for each digit in the multiplier
   b. Only one partial product is recorded for each digit in the multiplier
   c. Only one digit is recorder in the partial product of the multiplier
   d. Only two partial products are recorded for each digit in the multiplier

Brief reasoning:

………………………………………………………………………………………………........

…………………………………………………………………………………….………………

……………………………………………………………………………..……………………

8. The Seychelles' police department has 17 cars and motorcycles. The total number of wheels on the cars and motorcycles is 48. How many police cars does the police department have?

   a. 13
   b. 7
   c. 15
   d. 6

Brief reasoning:

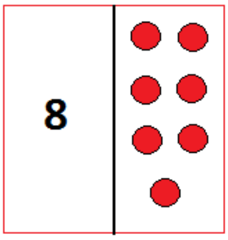
……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

9. Rational counting (e.g. one-to-one correspondence between items being counted and saying the number) is the ultimate goal of instruction on counting. The diagram below can be used to help children with:

   a. Counting back
   b. Counting on
   c. Skip counting
   d. Counting all



Brief reasoning:

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

10. Hazel who is a second grade pupil was asked to model two-digit numbers. Her work is presented below. Hazel uses varied expressions in this exercise. Can you comment on Hazel's work?

Meaning of Numbers

Task: Use the Popsicle sticks to represent numbers.
Write how you modeled each number

Hazel's work:

52 5 bundles of ten and 2 singles
47 4 tens and 7 singles
29 2 groups of ten and 9 ones
40 4 groups of ten
7 7 singles and 0 bundles

a. She did not understand the activity.
b. It is wise to describe events in different ways.
c. She cannot use singles and tens in the same activity.
d. She cannot use bundles and groups in the same activity.
e. She seemed to have understood the activity, but failed to mention the word Popsicle in her work.

Brief reasoning:

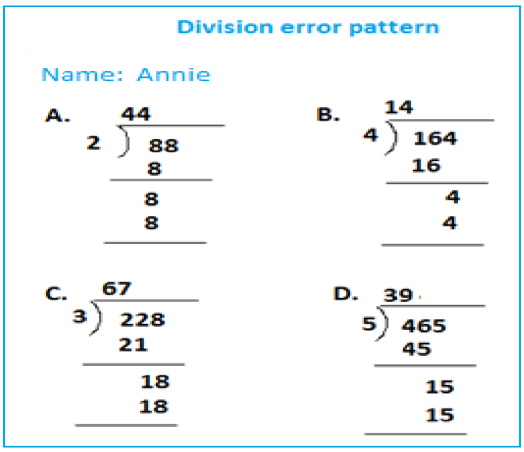
……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

---

11. How might you help Annie with her long-division?



a. She should estimate result before beginning a new division problem.

b. She should record the zeros in the final subtraction.
c. She need to learn how to place the quotients.
d. Needs to better understand the role of place value in long division.

Brief reasoning:

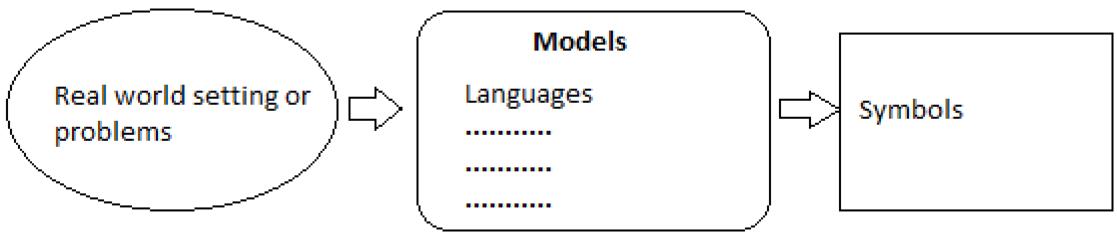
……………………………………………………………………………………………........

……………………………………………………………………………………………………

……………………………………………………………………………………………………

12. When introducing word problems, a teacher should encourage children to be creative in modelling the real world situation. Apart from languages, which other model children can use to model their problems.

A model for introducing operations with word problems



a. Mental images
b. Direct Instruction
c. Homework
d. Blackboard work

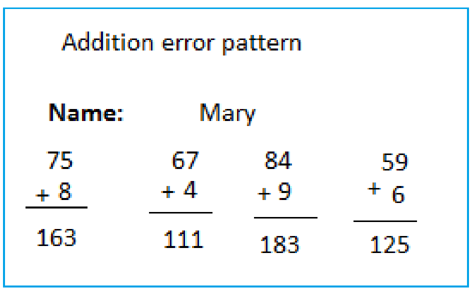
Brief reasoning:

……………………………………………………………………………………………........

……………………………………………………………………………………………………

……………………………………………………………………………………………………

13. How might you help Mary with her addition?



a. Use partial product algorithm
b. Build array with base ten blocks
c. Use base ten block to strengthen place value concepts
d. Teach her about number facts

---

14. Mrs. Bick asks pupils to classify classroom objects into four groups. What mathematical concepts and skills are used?
    a. Recognising similarities and differences
    b. Counting
    c. Relating numbers to numerals
    d. Recognising two-dimensional and three-dimensional shape

Brief reasoning:

…………………………………………………………………………………………........

…………………………………………………………………………………….…………………

……………………………………………………………………………..………………………

---

15. In order to identify all the prime numbers less than 200, a pupil writes each number from 1 to 200, and eliminates all the multiples of 2, then all the multiples of 3. To complete this task, the pupil will have to eliminate the multiples of which additional numbers?
    a. 5, 7, 9, 11
    b. 7, 9, 11, 13
    c. 5, 7, 11, 13
    d. 7, 11, 13, 17

Brief reasoning:

…………………………………………………………………………………………........

…………………………………………………………………………………….…………………

……………………………………………………………………………..………………………

16. Which type of diagnosis goes with the pupil sample error pattern below?

a. Fact errors
b. Sign discrimination errors
c. Renaming errors
d. Strategy errors

$$\begin{array}{r} 49 \\ \underline{17} \\ 32 \end{array} \qquad \begin{array}{r} 253 \\ \underline{174} \\ 427 \end{array}$$

Brief reasoning:

…………………………………………………………………………………………........

……………………………………………………………………………….………………

……………………………………………………………………..………………………

---

17. Below is an excerpt from the independence worksheet to be given to pupils who have just demonstrated accuracy in solving problems with two digit divisors and one or two digit quotients, in which estimating produces proper quotient. Indicate the appropriate examples.

A. $23\overline{)989}$ B. $34\overline{)148}$ C. $76\overline{)793}$

D. $58\overline{)2938}$ E. $31\overline{)283}$ F. $49\overline{)1638}$

Brief reasoning:

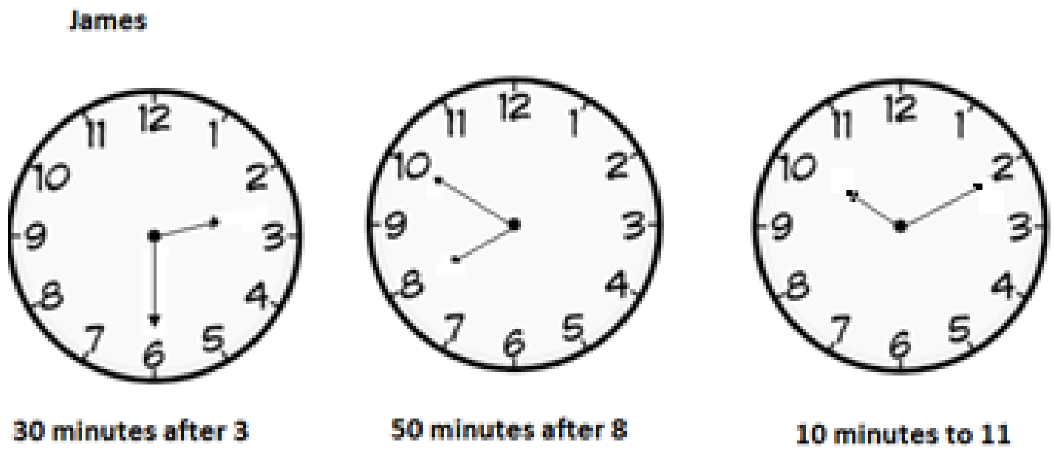
…………………………………………………………………………………………........

……………………………………………………………………………….………………

……………………………………………………………………..………………………

---

18. Tell the probable cause of the pupil's error below



a. James is still confused with telling time minutes before the hour
b. James is still confused with telling time minutes after the hour
c. James is still confused with telling the hour time
d. James is still confused with number facts

Brief reasoning:

…………………………………………………………………………………………........

………………………………………………………………………………….………………

…………………………………………………………………………..…………………

SECTION B (Open Ended)

Answer all questions in the space provided

19. Below are errors made by pupils on the given problem

Michel	Cheryl		Paul	
25	25	$5\overline{)99}$ = 19.8	25	$5\overline{)100}$ = 200
15	15	5	15	
17	17	49	17	
21	21	45	21	
+22	+ 22	40	+ 22	
100	99		100	

Jill played five basketball games. She scored 25 points in the first game, 15 points in the second game, 17 points in the third game, 21 points in the fourth game and 22 points in her last game. What was her average point?

Specify the remediation for each error

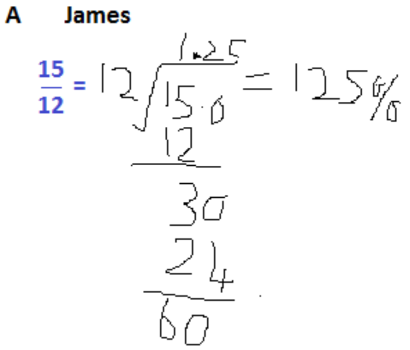
Michel…………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

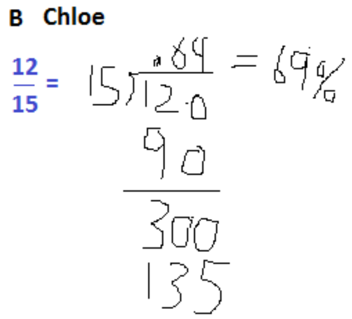
Cheryl…………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

Paul……………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

---

20. Below are errors made by pupils. Specify the probable cause of each error. Andrew took 15 shots, he made 12 of the shots. What percent of his shots did he make?





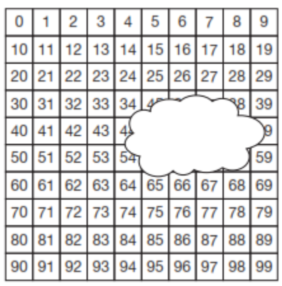
A James: ……………………………………………………………………………………..

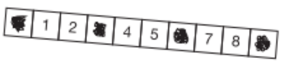
B Chloe: ……………………………………………………………………………………….

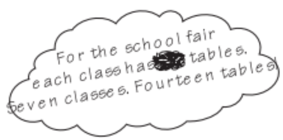
---

21. Teachers can use paint splashes, clouds and ink blots to explain why some numbers on a (e.g. number line, sum or word problems) cannot be read. What is the purpose of such activity?

a.







Answer……………………………………………………………………………………

....

....

..……………………………………………………………………………………………

---

22. Bryan was asked to do this multiplication problem below.

$$\begin{array}{r} 138 \\ \times\ 29 \\ \hline \end{array}$$

He worked out the problem in this way. 138 x 2 = 276. Then 138 x 9 = 1242. Then he added 276 and 1242. He knew that his answer was incorrect as it seemed too small. What should he have done differently? Identify this pupil's misconception and describe an appropriate strategy to counteract this misconception.

Answer:...

....

---

23. Below is a number grouping activity form for children. Using a model number greater than 35, fill in this sample activity form below which you would use with a class when developing their understanding of numeration.

Grouping Activities Form

Name: ____

I had ____________________ buttons

I made______________ groups of ____________ buttons and________

I made______________ groups of ____________ buttons and________

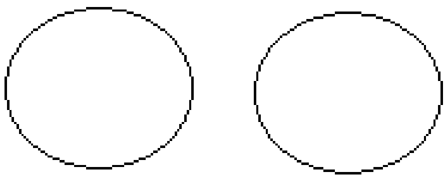
I made______________ groups of ____________ buttons and________

I made______________ groups of ____________ buttons and________

I made______________ groups of ____________ buttons and________

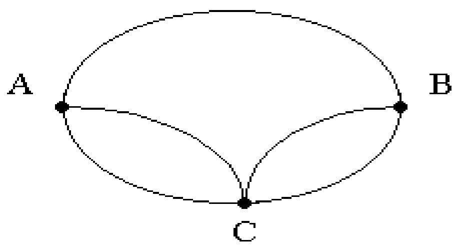
---

24. Draw diagrams to correspond to the given fraction.

$\frac{3}{2} =$ 

---

25. Amy has to visit towns B and C in any order. The roads connecting these towns with her home are shown on the diagram. How many different routes can she take starting from A and returning to A, going through both B and C (but not more than once through each) and not travelling any road twice on the same trip?



Answer:

END OF TEST

APPENDIX 18 - Teachers' MKT Test (Post-test)

TEACHERS' MKT TEST (Post-test)

Date:

Please enter the last 4 digits of your mobile phone in the box on the right. These digits will be used solely by the researcher for the matching up of the tests.

SECTION A [multiple-choice]

Instructions: Please answer all questions. Read all the answer choices and circle the best answers for each question. At the end of each question give a brief reasoning behind you answer.

1. The marked price of shirts in a store is Rs30. During one week, the store sells m shirts at the marked price and n shirts discounted 10% of the marked price. Which of the following is an expression of the store revenue from shirts sold during that week?

f) 30m + 30n
g) 30m + 27n
h) 30(m + 1n)
i) 27m + 30n
j) 27m + 27n

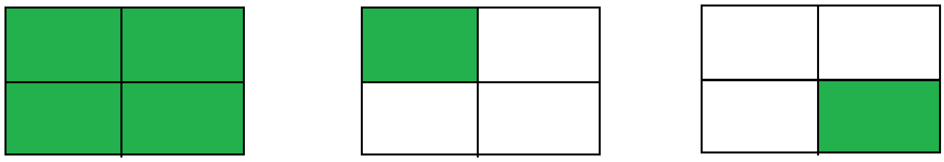
Brief reasoning:

……………………………………………………………………………………………..........

……………………………………………………………………………………………………

……………………………………………………………………………………………………

2. When teaching fractions, a teacher chooses to represent a whole by these 3 rectangles below.



What fraction of the whole is that teacher illustrating?

e) 3 wholes
f) 5/12
g) 2/4
h) 3/12

Brief reasoning:

…………………………………………………………………………………………........

……………………………………………………………………………….………………

………………………………………………………………………..………………………

---

3. Mrs Bick gave her class some fraction operations to do as homework. One pupil produced the results below. What problem is that pupil is having here?

1/2 x 1/6 = 1/12   2/3 x 2/3 = 4/3   2/7 x 7/8 = 14/56   3/8 x 3/8= 9/8

e. The pupil does not know how to multiply some numbers correctly.
f. The pupil made mistakes.
g. The pupil has not understood multiplication algorithm for fractions.
h. The pupil does not understand the concept of fractions.

Brief reasoning:

…………………………………………………………………………………………........

……………………………………………………………………………….………………

………………………………………………………………………..………………………

4. Which algorithm of subtraction would you encourage your pupils to use?

A	**B**	**C**

$\begin{array}{r} {}^{5}\cancel{6}\;{}^{11}\cancel{2}\;{}^{1}5 \\ -\;1\;\;4\;\;7 \\ \hline 4\;\;7\;\;8 \end{array}$	$\begin{array}{r} {}^{5}\cancel{6}\;{}^{9}2\;{}^{1}5 \\ -\;1\;\;4\;\;7 \\ \hline 4\;\;7\;\;8 \end{array}$	$\begin{array}{r} 6\;{}^{1}2\;{}^{1}5 \\ -\;1^{1}\;4^{1}\;7 \\ \hline 4\;\;7\;\;8 \end{array}$

f. Algorithm A because it is easier for pupils.
g. None of the above
h. Algorithm B because it is easier for pupils.
i. Any one of the three algorithms as long as they understand
j. Algorithm C because it is easier for pupils.

Brief reasoning:

……………………………………………………………………………………………........

……………………………………………………………………………………………………

……………………………………………………………………………………………………

---

5. **Problem 1:** A bag of 12 stocks were emptied on the floor, and two children volunteered to count them and it was all agreed that there were 12 socks. The question posed to the class was, when the socks were put back together in pairs, how many pairs of socks would that be?
   Problem 2: Six friends went out for a Chinese meal together. How many chopsticks would they need for them to have a pair each? (*Adapted from Mike Askew: Transforming Primary Mathematics*)

   Why is it that some pupils would not see the mathematical connection between these two problems?

e. The mathematical connection is not obvious to children.
f. Socks are socks and chopsticks are chopsticks.
g. There is the natural drive to look for the correct answers, rather than understanding the underlying mathematics.
h. Children do not have a mindful approach to mathematics.

Brief reasoning:

……………………………………………………………………………………………........

…………………………………………………………………………………………………

…………………………………………………………………………………………………

---

6. The operation below in this question involves teaching pupils decomposition with manipulatives to solve a story problem using subtraction of 3-digit numerals.

$$\begin{array}{r} 862 \\ -374 \\ \hline 488 \end{array}$$

Which incorrect instruction should not be in the list below?

f. Tell stories to match the numbers in the problems.
g. Introduce the regrouping and renaming subtraction model.
h. Introduce subtraction concepts.
i. Plan for a small group re-teach.
j. Ask pupils to accurately model several problems.

Brief reasoning:

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

7. When developing the traditional multiplication algorithm with children (see example below), they should be encouraged to think of how to shorten the algorithm. This can happen by:

H	T	U	H	T	U
	2	4		2	4
	X	3		X	3
	1	2		7	2
	6	0			
	7	2			

e. Only one multiplier is recorded for each digit in the multiplier
f. Only one partial product is recorded for each digit in the multiplier
g. Only one digit is recorder in the partial product of the multiplier

h. Only two partial products are recorded for each digit in the multiplier

Brief reasoning:

…………………………………………………………………………………………........

……………………………………………………………………………….………………

……………………………………………………………………….………………………

8. The Seychelles' police department has 17 cars and motorcycles. The total number of wheels on the cars and motorcycles is 48. How many police cars does the police department have?

   e. 13
   f. 7
   g. 15
   h. 6

Brief reasoning:

…………………………………………………………………………………………........

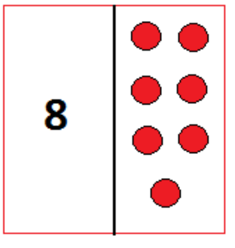
……………………………………………………………………………….………………

……………………………………………………………………….………………………

---

9. Rational counting (e.g. one-to-one correspondence between items being counted and saying the number) is the ultimate goal of instruction on counting. The diagram below can be used to help children with:

   e. Counting back
   f. Counting on
   g. Skip counting
   h. Counting all



Brief reasoning:

…………………………………………………………………………………………........

………………………………………………………………………………………………

………………………………………………………………………………………………

10. Hazel who is a second-grade pupil was asked to model two-digit numbers. Her work is presented below. Hazel uses varied expressions in this exercise. Can you comment on Hazel's work?

Meaning of Numbers

Task: Use the Popsicle sticks to represent numbers.
Write how you modeled each number

Hazel's work:

52 5 bundles of ten and 2 singles
47 4 tens and 7 singles
29 2 groups of ten and 9 ones
40 4 groups of ten
7 7 singles and 0 bundles

f. She did not understand the activity.
g. It is wise to describe events in different ways.
h. She cannot use singles and tens in the same activity.
i. She cannot use bundles and groups in the same activity.
j. She seemed to have understood the activity but failed to mention the word Popsicle in her work.

Brief reasoning:

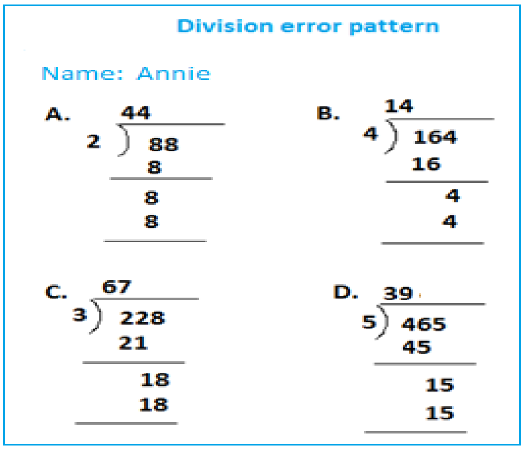
………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

---

11. How might you help Annie with her long division?



e. She should estimate result before beginning a new division problem.
f. She should record the zeros in the final subtraction.
g. She needs to learn how to place the quotients.
h. Needs to better understand the role of place value in long division.

Brief reasoning:

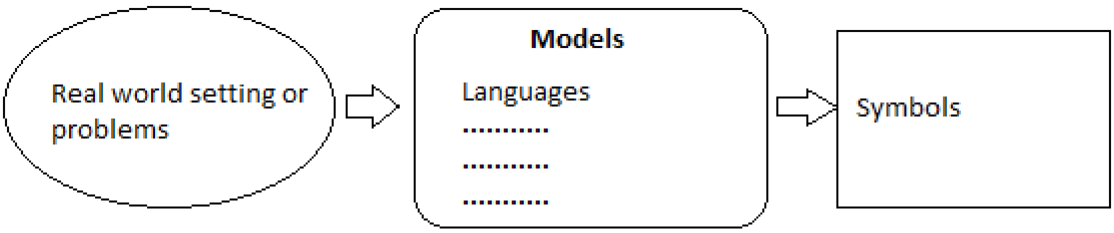
………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

12. When introducing word problems a teacher should encourage children to be creative in modelling the real world situation. Apart from languages, which other model children can use to model their problems.

A model for introducing operations with word problems



e. Mental images
f. Direct Instruction
g. Homework
h. Blackboard work

Brief reasoning:

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

---

13. How might you help Mary with her addition?

    e. Use partial product algorithm
    f. Build array with base ten blocks
    g. Use base ten block to strengthen place value concepts
    h. Teach her about number facts

Addition error pattern

Name: Mary

75	67	84	59
+ 8	+ 4	+ 9	+ 6
163	111	183	125

---

14. Mrs. Bick asks pupils to classify classroom objects into four groups. What mathematical concepts and skills are used?

    e. Recognising similarities and differences
    f. Counting
    g. Relating numbers to numerals
    h. Recognising two-dimensional and three dimensional shape

Brief reasoning:

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

---

15. In order to identify all the prime numbers less than 200, a pupil writes each number from 1 to 200, and eliminates all the multiples of 2, then all the multiples of 3. To complete this task, the pupil will have to eliminate the multiples of which additional numbers?
   e. 5, 7, 9, 11
   f. 7, 9, 11, 13
   g. 5, 7, 11, 13
   h. 7, 11, 13, 17

Brief reasoning:

……………………………………………………………………………………………........

……………………………………………………………………………………..………………

……………………………………………………………………………..……………………

16. Which type of diagnosis goes with the pupil sample error pattern below?

   e. Fact errors
   f. Sign discrimination errors
   g. Renaming errors
   h. Strategy errors

$$\begin{array}{r} 49 \\ \underline{17} \\ 32 \end{array} \qquad \begin{array}{r} 253 \\ \underline{174} \\ 427 \end{array}$$

Brief reasoning:

……………………………………………………………………………………………........

……………………………………………………………………………………..………………

……………………………………………………………………………..……………………

---

17. Below is an excerpt from the independence worksheet to be given to pupils who have just demonstrated accuracy in solving problems with two digit divisors and one or two digit quotients, in which estimating produces proper quotient. Indicate the appropriate examples.

A. $23\overline{)989}$ B. $34\overline{)148}$ C. $76\overline{)793}$

D. $58\overline{)2938}$ E. $31\overline{)283}$ F. $49\overline{)1638}$

Brief reasoning:

……………………………………………………………………………………………........

……………………………………………………………………………….………………

………………………………………………………………………………..………………………

---

18. Tell the probable cause of the pupil's error below

e. James is still confused with telling time minutes before the hour
f. James is still confused with telling time minutes after the hour
g. James is still confused with telling the hour time
h. James is still confused with number facts

Brief reasoning:

……………………………………………………………………………………………........

……………………………………………………………………………….………………

SECTION B (Open Ended)

Answer all questions in the space provided

19. Below are errors made by pupils on the given problem

Michel	Cheryl		Paul	
25	25	$5\overline{)99}$ = 19.8	25	$5\overline{)100}$ = 200
15	15	5	15	
17	17	49	17	
21	21	45	21	
+22	+ 22	40	+ 22	
100	99		100	

Jill played five basketball games. She scored 25 points in the first game, 15 points in the second game, 17 points in the third game, 21 points in the fourth game and 22 points in her last game. What was her average point?

Specify the remediation for each error

Michel……………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

Cheryl……………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

Paul………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

---

20. Below are errors made by pupils. Specify the probable cause of each error.

Andrew took 15 shots, he made 12 of the shots. What percent of his shots did he make?

A **James**

$\frac{15}{12} = 12\overline{)15.0}$ = 1.25 = 125%

12
30
24
60

B **Chloe**

$\frac{12}{15} = 15\overline{)12.0}$ = .64 = 64%

90
300
135

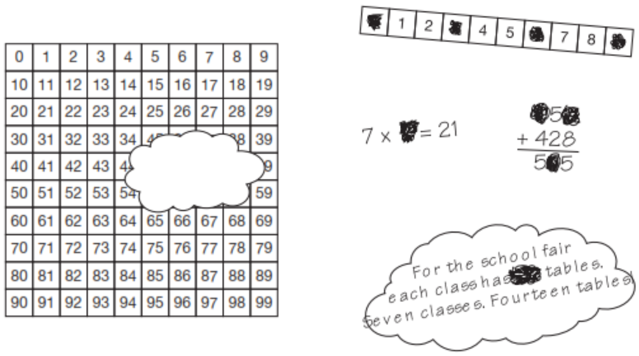
A James: ……………………………………………………………………………………………..

B Chloe: ……………………………………………………………………………………………….

---

21. Teachers can use paint splashes, clouds and ink blots to explain why some numbers on a (e.g. number line, sum or word problems) cannot be read. What is the purpose of such activity?

b.



Answer……………………………………………………………………………………………

……………………………………………………………………………………………

---

22. Bryan was asked to do this multiplication problem below.

$$\begin{array}{r} 138 \\ \times\ 29 \\ \hline \end{array}$$

He worked out the problem in this way. 138 x 2 = 276. Then 138 x 9 = 1242. Then he added 276 and 1242. He knew that his answer was incorrect as it seemed too small. What should he have done differently? Identify this pupil's misconception and describe an appropriate strategy to counteract this misconception.

Answer:

23. Below is a number grouping activity form for children. Using a model number greater than 35, fill in this sample activity form below which you would use with a class when developing their understanding of numeration.

Grouping Activities Form

Name: ______________________________

I had ____________________ **buttons**

I made______________ **groups of** ____________ **buttons and**________

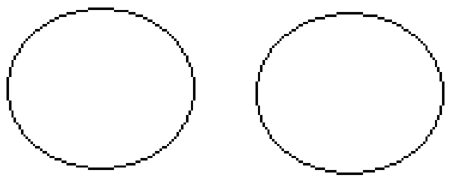
I made______________ **groups of** ____________ **buttons and**________

I made______________ **groups of** ____________ **buttons and**________

I made______________ **groups of** ____________ **buttons and**________

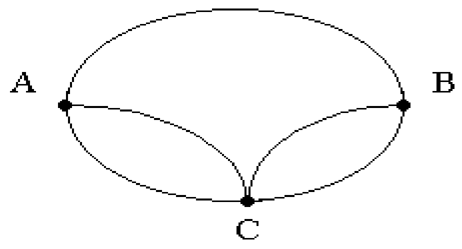
I made______________ **groups of** ____________ **buttons and**________

24. Draw diagrams to correspond to the given fraction.

$\frac{3}{2} =$ 

---

25. Amy has to visit towns B and C in any order. The roads connecting these towns with her home are shown on the diagram. How many different routes can she take starting from A and returning to A, going through both B and C (but not more than once through each) and not travelling any road twice on the same trip?



Answer:

END OF TEST

APPENDIX 19 - The Kolmogorov-Smirnov Test

Tests of Normality

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.091	57	.200*	.969	57	.148

APPENDIX 20 - The Levene's test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Group1	17	45.5294	15.08773	3.65931
	Group2	41	47.5610	14.32838	2.23772

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
							Std. Error Difference	95% Confidence Interval of the Difference	
Score	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference		Lower	Upper
Equal variances assumed	.513	.477	-.484	56	.630	-2.03156	4.19703	-10.43923	6.37610
Equal variances not assumed			-.474	28.604	.639	-2.03156	4.28928	-10.80941	6.74629

APPENDIX 21- Independent Samples T-Test on the Pre-intervention MKT Test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Group1	17	45.5294	15.08773	3.65931
	Group2	41	47.5610	14.32838	2.23772

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	.513	.477	-.484	56	.630	-2.03156	4.19703	-10.43923	6.37610
	Equal variances not assumed			-.474	28.604	.639	-2.03156	4.28928	-10.80941	6.74629

APPENDIX 22 - Independent Samples T-Test on the Post-intervention MKT Test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Group1	17	49.6471	14.00420	3.39652
	Group2	31	47.0968	15.09824	2.71172

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	.136	.714	.574	46	.569	2.55028	4.44455	-6.39612	11.49669
	Equal variances not assumed			.587	35.258	.561	2.55028	4.34624	-6.27074	11.37131

APPENDIX 23- Independent Samples T-Test on Post-MKT Self-efficacy Mean for the Control and Experimental Groups

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	Control	5	4.6880	.16022	.07165
	Experimental	5	4.9220	.13535	.06053

Independent Samples Test

		Equality of Variances		t-test for Equality of Means					Interval of the	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
score	Equal variances assumed	.873	.377	-2.495	8	.037	-.23400	.09380	-.45030	-.01770
	Equal variances not assumed			-2.495	7.783	.038	-.23400	.09380	-.45135	-.01665

APPENDIX 24 - Paired-samples T-Test on Pre and Post-intervention MKT Self-efficacy Domain Mean

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	4.5920	5	.13008	.05817
	After	4.9220	5	.13535	.06053

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Before & after	5	.417	.485

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Before - After	-.33000	.14335	.06411	-.50800	-.15200	-5.147	4	.007

APPENDIX 25- Independent Samples T-Test on MTSE

Group Statistics

	Group1	N	Mean	Std. Deviation	Std. Error Mean
Score	Group1	23	4.6187	.79058	.16485
	Group2	23	4.4896	.56800	.11844

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score	Equal variances assumed	1.260	.268	.636	44	.528	.12913	.20298	-.27995	.53821
	Equal variances not assumed			.636	39.934	.528	.12913	.20298	-.28113	.53939

APPENDIX 26- Profile of Participants

♦ Azuza

Azuza, the youngest participant at age 26, was the most vibrant, inspiring and most qualified participant in the study. She held a bachelor's degree in primary education, majoring in mathematics and science from an African University. She had four years of teaching experience and taught from year 2 to year 4. Azuza was very keen to take part in the study. Azuza declared that she took up teaching as a career because she liked both teaching and children. She acknowledged in the interview that she enjoyed doing the reflective journal even if it was time consuming. Azuza had never been exposed to RP during her university teacher training. She found the journal writing and the keeping of journals to be very beneficial. "While I was writing it made me reflect thoroughly through the process. Through this, you actually see where you went wrong. Like when I did my first one, and when I did my second journal, I read the first one, and I compared it. It's different. Two different things."

♦ Bryony

Bryony was the most talkative participant in the study. She explained that she cares a lot about children and this keeps her in the profession. She worked in the same school as Karin. She has a very bold character, and in the interview, she constantly expressed what were her affective traits of teaching. She held a diploma in primary education, majoring in mathematics and science. She had 9 years of teaching experience and teaches in year 3 and year 4. She made significant gains in her MKT scores and was classified as a Group 2 case. Bryony made remarks regarding her involvement in the study.

"Frankly there were times when I wanted to stop. I was under a lot of pressure. Then I say ok. If I was I in the place of sir Bryan, I wanted some, you need me to be able to do the study. Then I say that maybe tomorrow it will be my turn. I really motivated myself to fulfil your study requirements and I feel good about it now. I really like this reflective journal. It is of great benefit for us teachers. It is very much relevant, but if we were to do every week! "

Bryony also claimed that she could not think of doing anything else apart from teaching. She explained that the PIES mnemonic strategy supported her teaching and claimed that she took more time to study her pupils. However, she also claimed that the reflective writing was time consuming and at some point in the study she wanted to give up. She explained that there had been some changes in her mathematical knowledge. She said that she had become more reflective and took more time to reflect on her teaching and the way pupils learn. In her own words: "..I will take more time to analyse things that are happening in my teaching, about me as a teacher personally, about the pupils and the way that they learn and the way that I am teaching."

- **Erika**

Erika was a white 38-year-old female teacher, also a deputy teacher in her department. She held a diploma in primary education. She was insightful and optimistic about the improvement of learning in her school. She had 20 years of teaching experience and was teaching in year 3 at the time the of data collection. Erika expressed great love for children. She was classified as a Group 3 teacher. Erika was very much involved in this study. She was a contact person for her school and made sure that her colleagues completed the required research tools in time for collection. Erika scored less in her post-test than pre-test. In the interview Erika explained that: "…. despite time constraint for reflection, if teachers could embark on this, being a reflective practitioners, there would be a difference in performance."

Erika did not just care about her classes benefiting from this current study, but wished that the whole school could join in. She spoke well about using the PIES mnemonic strategy to teach mathematical word problems. She said that it had considerably supported her teaching. She is well remembered for saying: "Sir, to tell you the truth it has not been easy, it is not easy to write a reflective journal." Erika said that the RP treatment had brought changes to her mathematical knowledge, and at the time of the interview she claimed that the volume of change would have been bigger if the treatment time was longer. Those changes were in terms of understanding the teaching of word problems and how to address pupils' learning difficulties.

- **Fumi**

Fumi was a 46-year-old primary teacher and worked at the Platte school together with Tilly. She was an experienced mathematics teacher with 25 years of teaching experience. She taught mathematics and science. At the time of the data collection, she was teaching in year 5 and 6. She was classified as a Group 2 category after having made a 14-point gain in her post-test. Fumi was important to the study in the sense that she provided an inside perspective of the difficulties her school was having with the teaching of primary mathematics. She was the type of person who would not just lament over the problems and issues but would suggest possible solutions as well. However, Fumi was also frustrated and stressed-out with her career because the mathematics results in her school were not improving. Fumi was quite encouraging about this study through the following words:

"For this RP I would encourage all the teachers teaching, not only mathematics, but maybe other subjects to use this method. At least once a week where we sit down and analyse our teaching. Maybe it will help us to better prepare our pupils. I will encourage other teachers to use it. It will help us to grow professionally."

- **Hana**

Hana was a 26-year-old primary teacher, working in the same school as Vignette and has been teaching for eight years. Like Erika, Hana was optimistic about the future performance of pupils in her school. She held a diploma in primary education, and at the time of being interviewed, Hana was teaching in year 3. She was classified as a Group 3 category after having made a loss of ten points in her post-test. Hana impressed this study with the high-quality content of her reflective journals. She explained that it is the love that she has for children that keeps her in the profession. Hana found the reflective journals useful: "…It also helped me to address my teaching, to reflect in depth. Because when I was doing the reflective writing. I was able to reflect on myself and on the pupil also." At the end of the interview she said that she would like to take up further studies if she was given the opportunity.

- **Beatrix**

The interview took place in the staffroom. At 10.a.m in the morning the staffroom was surprisingly empty because all the teachers at the Cosmoledo school were in class. First impressions were that Beatrix was a reserved person, but when you got to know her, she could be quite talkative. Talkative in the sense that she would naturally provide you with the type of information she thought you were pursuing. Professionally, Beatrix was a 30-year-old female teacher teaching in year 3 and 4. She had a diploma in primary education, with 12 years of mathematics teaching experience. Beatrix was classified as a Group 3 teacher due to her eight points loss in the post-test. In the interview, Beatrix, explained that getting involved in this study has transformed her teaching. She explained that her love for children keeps her in the profession; and getting involved in the research study has made her more positive towards the teaching of mathematics. In the interview, she made this comment about the PIES mnemonic strategy:

"Most of the time when teaching word problem, you use the problem itself. But rarely you would find the problem being accompanied by pictures. So, you could use it like a story to know like this is the problem, this is what happened, and I want to know the answer. So, it helped me to help the pupil better understand word problems."

- **Karin**

Karin, aged 45, held a diploma in primary education. She taught at the Bird primary school together with Bryony. At the time of the data collection, Karin was teaching mathematics in year 5 and year 6; and had 25 years of teaching experience. Karin explained that teaching was a job she had wanted to do since she was a child. Karin encouraged both her colleagues to stay in the profession and her pupils to learn. The field notes revealed that Karin was an instrumental character and a valuable contributor towards the research. She also encouraged her colleagues to get involved in the study. She took the responsibility of making sure that the research documents were always ready for collection. The interview extract below reveals her initial view of the research.

"I was a bit reluctant to get involved in the study due to the number of tasks involved and I said wow, that's a lot. But then, I said okay let me take the challenge and try, and there I could see that I was wrong. It is a practice that we all have to use and maybe when I complete the process, I would like to present one of the journals to my colleagues."

- **Charlotte**

Charlotte taught at the Bijoutier primary school together with Harriet. Aged 48, she was the oldest participant in the study. Charlotte explained that she was burned-out, depressed, and would like to have further training as a teacher. She held a certificate in primary education and taught in year 4 and 5. Charlotte was put in Group 4 and had a gain score (-4). A negative gain score means that she scored less on her post-test than pre-test. She was a bit weak in the writing of her reflective journals and acknowledged that she needed to further develop her teaching of mathematics. The excerpt below highlights an important remark she made during the interview pertaining to her professional development:

"Every year after year the mathematics national exam is not good. Maybe if we get the chance to get some training, maybe it will improve for the betterment of our country and our school."

- **Nadine**

Nadine was a young, softly speaking, early childhood female teacher with only ten years in the teaching profession. Nadine taught at the Poivre school together with Andrea. She was the only participant with Montessori training and experience. Alongside mathematics, she taught science and languages as well. Nadine was not very keen at the start of the study but was one of the most motivated and interesting participants in the latter half of the study. At the time of being interviewed Nadine was teaching mathematics to primary 2 pupils. There is a noted incident in the field notes where Nadine was not too happy with the fact I could not attend one of her mathematics class visits. The in-depth interview with Nadine lasted for 22min: 26 seconds. She was a valuable contributor to the study, with impressive journal-writing skills. Nadine provided the study with a clear journal. Below is Nadine's feedback on the intervention study from her interview:

"…Erm, that is the only constraint I had, but I have benefited from it, the children as well. I find it very interesting."

Gibbs (1988) explains that you can only learn from your written journal if you have enough courage to face yourself as you are. Nadine was the participant with the most gain score of 30 points, and she was put on her own in Group one by the cluster analysis.

- **Vignette**

Vignette was a 41year old teacher working at Aldabra school together with Hana. Aldabra school is the most rural school in the south of the Island. During the interview, Vignette explained that she liked teaching and wanted the pupils to learn. She further explained that she was greatly loved by her colleagues and pupils due to her attitudes. Vignette was teaching in year 5 during the time of data collection. Vignette is well remembered during the interview for saying how she does reflection in action and re-iterating that the teaching and learning of primary mathematics has been a problem for a while.

"…When I look at the paper, I realise that sometimes we do not take much time to reflect, we do reflect, but not much during the lesson but after the lesson, for example when washing my clothes on the rock or onboard a bus."

Vignette was the type of person who would speak her mind. She acknowledged that there was one particular question in the MKT test that had been giving her real problems and she wanted to know the answer (see Preface). From the very first day Vignette was willing to take part in the study. In the later part of the interview, she explained that the reflective journal helped her to focus on her teaching weaknesses.

- **Zara**

Zara was a 35-year-old teacher working at Coetivy school together with Erika. Coetivy school is the most rural school in the north of the Island. At first, she was reluctant to get involved in the study, claiming that she was in lower level classes. After talking the study through with her, she was willing to participate. During the interview Zara revealed important information for the fieldnotes about mathematics education in her school. Zara was teaching in primary year one at the time of being interviewed. She was classified as a Group 4 teacher type and scored better in her MKT post-test than pre-test. When discussing what RP has brought to her teaching, Zara made this remark:

"Since I have written one journal so far, I find it very effective. I will be able to assess pupils' learning, and by doing this type of reflection on a weekly basis will help to make a difference in the teaching and learning especially about word problem."

- **Harriet**

Harriet was a 32-year-old teacher working at Bijoutier school together with Charlotte. Harriet held a diploma in primary mathematics and was teaching in year 5 and 6 at the time of being interviewed. She was classified as a Group 2 teacher type and scored far better in her MKT post-test than her pre-test. Harriet could be labelled as 'chatty' but she was the type who would speak her mind. The quotation below, from her interview, typifies her character:

"For the keeping of the reflective journal it helps you to make a reference to. Ah, in my first journal I said that this did not work. So, it's like a follow up, in the next lesson we tried to do something else to make it work out. And it is not just something that I am just saying it went like this. It was really an experience."

- **Libby**

We arranged to meet in Libby's classroom for the interview. She was always serious and timid in appearance, and this did not deter her pupils from making noise around her class during the interview. However, the noise did not affect the quality of the interview. Libby was a 33-year-old primary school generalist teacher who had been teaching for 13 years. Being a generalist meant that she could teach from Crèche to P6. She said that she liked teaching mathematics because she enjoyed mathematics when she was at school. She taught at the Cosmoledo school together with Beatrix. Cosmoledo school is the most rural school in the north of the Island. Libby was teaching in year 3 at the time of the research. The cluster analysis placed her in Group 2 and she made a gain of 6 points in her post-test. She explained that most of her experience has been with the Cosmoledo school. She further explained that she was encouraged by the mathematics coordinator to take part in the study, but ultimately made her own decision to participate, as she thought that her participation could be useful for her professional development. She said that her participation in the study had improved her teaching of problem solving.

♦ Tilly

Tilly was a 29-year-old teacher, and she was teaching in primary 3 (P3) at the Platte school at the time of being interviewed. She worked in the same school as Fumi. Tilly had long been interested in being a teacher. She had been teaching mathematics for seventeen years. She still finds the profession challenging. Tilly held a diploma in primary education and had 9 years of teaching experience. She described her classroom experience as follows:

"Teaching mathematics in P4 is quite challenging as the pupils are in transition stage. They sometimes have difficulties to grasp a concept quickly. Students sometimes have problems with problem solving."

However, Tilly stood out from the rest of the participants at the outset and immersed herself fully in the study and could be trusted to provide all the research data as necessary. Through classroom visits, I was able to witness a dramatic change in her confidence to teach mathematics. Her increased confidence when talking about her next lessons was inspiring to hear.

♦ Marla

Marla, aged 32, held a first degree in Chemistry and specialised in secondary education. Not much could be revealed about her personal profile in this study, however she taught primary mathematics to year 5 and 6 at Assumption school. We first met in the staffroom, and there she revealed to me why as a chemistry specialist she is now teaching mathematics and science in the primary school. Marla was not very comfortable with the teaching of mathematics. This is what she said when I asked her about her confidence in primary mathematics:

"Confidence in teaching mathematics! Like I said, I was trained to teach specifically chemistry. So, teaching mathematics is a challenge for me."

However, she convinced herself that her participation in the study could provide her with more knowledge and improve her self-confidence. She mentioned that teaching is a "dream job" for her. Marla was classified as a Group 4 teacher after she scored 2 points less in her post-test than her pre-test.

♦ Andria

"Don't call me if you have not used your colleagues." The above excerpt is Andria's favourite line to pupils who sought her help in the mathematics class. Andria was a 42-year-old, foreign, female teacher who taught mathematics in year 5 and 6 at the time of being interviewed. Andria is considered a special participant in the study who was eager to get involved from the very beginning. She was very open about issues relating to the teaching of mathematics in Seychelles. She was also the first participant to complete the first weekly journal for this study, and the first participant who was observed implementing the PIES strategy. When the study was introduced to her school, she was able to convince her reluctant colleagues to take part. Andria taught at the Poivre school together with Nadine. Andria had been teaching for the past ten years. She admitted that the implementation of the PIES strategy had immensely improved her self-management skills.

- **Zak**

Zak was the only male participant in the study and was teaching at the Astove primary school. Zak is described as marvellous because, as he explained, he went above and beyond his job-description. Zak was attracted to teaching by the same motives as the females. He is a 28 years old and his teaching career stretched across 8 years. Zak had a diploma in primary education and taught mostly in year 6. He was the participant with the longest interview, where he spoke at length about his wish for more professional development in his school. In the interview he explained that his focus was not just on the academic side, but also on the holistic development of the pupils. He said that he would like to stretch the pupils academically to the maximum. In the interview Zak commented on how the intervention has improved his knowledge of content and pupils:

" ...How do children learn. If there is this weakness, how can I use my knowledge to impart that knowledge to that pupil. The knowledge of pupils itself. It is not personally for me because personally I see that I have a good basic in mathematics. Any method any strategy. I would be able to deliver because I have the knowledge. It is the knowledge of them." Zak claimed that he liked his job because there are challenges and rewards at the end.

APPENDIX 27- Table 7.3: Sources, Category, Sub-categories and Frequencies for Theme One

Theme 1: Scrutinising Practice to Enhance Performance						
Category	**Sub-categories**	**Total number of data sources (N=171)** *n* (%)	**Journal sources (N= 52)** *n* (%)	**Interview sources (N=17)** *n* (%)	**Survey (open-ended questions) (N=102)**	**Number of references (frequency)**
Informative and transformative reflections	Critical reflection	12 (28%)	3 (13%)	9 (27%)	0	27 (35%)
	Reflection on action	12 (28%)	6 (25%)	6 (18%)	0	25 (32%)
	Deeper and more meaningful reflection	10 (23%)	0 (0%)	10 (30%)	0	14(18%)
	Reflective writing is not a waste of time	9 (21%)	1(4%)	8(24%)	0	12(15%)

APPENDIX 28 - Table 7.4: Sources, Category, Sub-categories and Frequencies for Theme Two

Theme 2: Self-assessment Within a Transformative Process						
Category	**Sub-categories**	**Total number of data sources (N=86)** *n* (%)	**Journal sources (N= 52)** *n* (%)	**Interview sources (N=17)** *n* (%)	**Survey (open-ended questions) (N=17)**	**Number of references (frequency)**
Self-examination as a lens for learning	Positive attitude towards teaching	12(26%)	6 (22%)	6(30%)	0	14(23%)
	Exploring Belief beliefs, values and assumptions	10(21%)	0(0%)	10 (37%)	0	12(20%)
	Changes in assumptions and beliefs	9 (19%)	8(30%)	1 (5%)	0	14(23%)
	Changes in perspective	9 (19%)	2(7%)	7(35%)	0	13(22%)
	Self-evaluation	7 (15%)	1(4%)	6 (30%)	0	7(12%)

APPENDIX 29 - Table 7.5: Sources, Category, Sub-categories and Frequencies for Theme Three

Theme 3: Reshaping Perceptions of Capabilities						
Category	**Sub-categories**	**Total number of data sources (N=171)** *n* (%)	**Journal sources (N= 52)** *n* (%)	**Interview sources (N=17)** *n* (%)	**Survey (open-ended questions) (N=102)**	**Number of references (frequency)**
Efficacy beliefs and self confidence	High sense of efficacy	15 (25%)	7(28%)	8(31%)	0 (0%)	18
	Improved self-efficacy	11 (18%)	5(20%)	6 (23%)	0(0%)	19
	Self-confidence in teaching mathematics	35 (57%)	13(52)	12(46%)	10 (100%)	41

APPENDIX 30 - Table 7.6: Sources, Category, Sub-categories and Frequencies for Theme Four

Theme 4: Professional and Experiential Knowledge Growth for Change						
Category	**Sub-categories**	**Total number of data sources (N=171)** *n* (%)	**Journal sources (N= 52)** *n* (%)	**Interview sources (N=17)** *n* (%)	**Survey (open-ended questions (N=102)**	**Number of references (frequency)**
Acquisition of new knowledge	Knowledge of content and teaching (KCT)	46 (40%)	31 (46%)	15 (33%)	0 (0%)	90 (45%)
	Knowledge of content and pupils (KCS)	35 (30%)	18 (26%)	16 (35%)	1 (100%)	62 (31%)
	Specialised Content Knowledge (SCK)	12 (10%)	8 (12%)	4 (9%)	0 (0%)	11 (6%)
	Knowledge of curriculum	8 (7%)	3 (4%)	5 (11%)	0 (0%)	10(5%)
	Common Content Knowledge (CCK)	7 (6%)	2(3%)	5 (11%)	0 (0%)	11(6%)
	Improvement in teacher knowledge	8 (7%)	6(9%)	1(2%)	1(50%)	14 (7%)

APPENDIX 31 - Table 7.8: Sources, Category, Sub-categories and Frequencies for Theme Five

Theme 5: Awareness of Practice and Self-knowledge						
Category	**Sub-categories**	**Total number of data sources (N=171)** *n* (%)	**Journal sources (N= 52)** *n* (%)	**Interview sources (N=17)** *n* (%)	**Survey (open-ended questions) (N=102)**	**Number of references (frequency)**
Self-knowledge and awareness	Aware of professional weakness in practice	23 (26%)	23(28%)	0(0%)	0(0%)	32
	Self-awareness	12 (14%)	7(9%)	3(75%)	2 (100%)	18
	Awareness of good practice	15 (17%)	15 (18%)	0(0%)	0(0%)	17
	Aware of need for further professional development	12 (14%)	11(13%)	1(25%)	0(0%)	12
	More conscious of teaching and learning	11(13%)	11(13%)	0(0%)	0(0%)	14
	Aware that learning needs to take place in individual pupils	8(9%)	8(10%)	0(0%)	0(0%)	10
	Aware of pupils' weaknesses	7(8%)	7(9%)	0(0%)	0(0%)	9

APPENDIX 32 - Table 7.9: Sources, Category, Sub-categories and Frequencies for Theme Six

Theme 6: Changes in Teaching and Learning						
Category	**Sub-categories**	**Total number of data sources (N=171)** *n* (%)	**Journal sources (N= 52)** *n* (%)	**Interview sources (N=17)** *n* (%)	**Survey (open-ended questions (N=102)**	**Number of references (frequency) N=131**
Efforts to improve practice	Changes in teaching practice	33(29%)	15(26%)	16(36%)	2(17%)	42 (32.1%)
	Teacher learns something new and improves practice	23(20%)	9(16%)	13(29%)	1(8%)	24 (18.3%)
	Teaching for Social Justice	18(16%)	16(28%)	1(2%)	1(8%)	24(18.3)
	Improved skill sets	15(13%)	3(5%)	4(9%)	8(67%)	16(12.2%)
	Teacher has better engagement with teaching tasks	13(11%)	7(12%)	6(13%)	0(0%)	13(10%)
	Learn to be a more effective assessor	12(11%)	7(12%)	5(11%)	0(0%)	12 (9.1%)

APPENDIX 33- Table 7.10: Sources, Category, Sub-categories and Frequencies for Theme Seven

Theme 7: Creating Pupil-centred Learning Environments						
Category	**Sub-categories**	**Total number of data sources (N=171)** *n* (%)	**Journal sources (N= 52)** *n* (%)	**Interview sources (N=17)** *n* (%)	**Survey (open-ended questions) (N=102)**	**Number of references (frequency)**
Students' progress	Students learning something new	20(27%)	9(28%)	9(24%)	2(67%)	25
	Change in pupils learning	15(20%)	7(22%	8(21%)	0(0%)	17
	Students more engaged with tasks	11(15%)	5(16%)	6(16%)	0(0%)	12
	Co-construction of knowledge through collaborative enquiry	11(15%)	4(13%)	6(16%)	0(0%)	11
	Student-centred teaching	10(14%)	7(22%)	2(5%)	1(33%)	12
	Caring for pupils	7(9%)	0(0%)	7(18%)	0(0%)	8

APPENDIX 34 - Table 8.1: Sources of Self-efficacy for the Participants

Typology	Sources	Narrative examples
Mastery experience	• Teaching experience • Perspective and attitudes towards teaching • Subject knowledge • Self-Confidence • Passion for teaching • Innovative approaches • Teaching competence	"Before I was not using PIES where one has to draw. I was making a story. From that story they formulated their own problem. But I find this one very useful because from this one you are able to draw the picture, they you can also formulate a story with it. The PIES strategy can cater for all the pupils." [**Hana]** "I never did it for them sorry. I never did it for them. They are here to guide me. My focus is the pupils. I come here for the pupils. But this reflection turns things back to you as well, that I have to keep on reflecting, I do not have any choice." [**Harriet**] "When I first looked at PIES reading it, I say ok why not try it. And then for the first time when I tried it. It works like when we have small numbers for primary 3 and primary 2." **[Azuza]** "Ya. I did not have the confidence. Most of the time when I would teach a subject, I would go to the internet prior to just check or go check with other teachers, that now I do more. So, this is how like my confidence. Now I don't not have to say like, they would be saying things about me because I do not know much about this subject. So, if you do not know you just need to go out there and ask. My **confidence of asking when I do not know has changed greatly."** [**Azuza**] "They were quite a bit similar because the 3-based strategy you have to guide them and make them see the problem as a picture, and then try to put it down and then try to solve it. **So it was like a practice that I have been doing before.** It was similar but I do not know how to explain. I have been using it for word problems but not as a PIES. Before that I was also telling them that before they do the problem, they have to write down what you know from the problem and what you do not know you leave it blank. And then what are we going to find out to get the answer." [**Fumi**] "It has made me more aware that when teaching there are different components that I have to be taking care of. Yes, **I am confident in what I am doing,** but maybe sometimes we just teach out of our experience, but it helps us to realise that in teaching there are different steps and different components that we have to look at. To be more focused." [**Karin**] "Ermm. I was a bit reluctant to get involved in the study due to the number of tasks involved, and I said wow, that's a lot. **But then I said okay let me take the challenge and try**. There, I could see that I was wrong. It is a practice that we all have to use and maybe when I complete the process, I would like to present one of the journals to my colleagues." **[Karin]** "I think the biggest lesson for me is giving pupils an opportunity, in fact realising that I have different type of learners, so, giving them the opportunity to **express their understanding according to their way of learnin**g. That's the biggest lesson for me." [**Andria**] "The lesson was scaffolded so that in the beginning I controlled the process through modelling, gradually shifting the thinking load to pupils. Throughout the process the pupils and I were constructing the models together. I guided pupils through each step of problem solving by prompting them with questions that fostered their critical thinking and word problem solving using PIES." [**Andria**] "I realise that the lesson was on data, and **I had to create my own word problem to fit in the lesson**, The steps were introduced, and the pupils were able to follow and solve the word problem. The low achievers needed more manipulatives, and the real-life situation is understood, the word problem as picture were not enough for them." [**Nadine**. "If we have professional development, I would like to use this time to make the most of it. I do not see new things. I am in

		school; I am working, and I want to upgrade myself. We say professional development, but we talk about children's day, other issues. This type of chat is what I want to see happening in the school in order to help improve learning. Some teachers who have just completed their B.Ed, they have brought in new things, not necessarily in maths, but hey have brought in new things, especially for languages, new strategies. I am still using the new strategies that I have learnt from the B.Ed teachers. It has impacted me not to keep on only with the conventional chalk and board. This is what I want to see happening in schools." [**Zak**] "Alright, definitely, there is a boost in confidence. Why? One thing is that when you see your pupils, they are achieving, they are understanding concepts being taught, definitely you will feel good. In being reflective, you will sit back and think about how it went and while you mark their work you will see that this has helped in one way or another. You feel good about it. Definitely your confidence will be higher than before." [**Erika**]
Vicarious experience	• Support from colleagues • Support from pupils • Observation	"I have learnt when I was on the job training, some I have learnt from my **colleagues**, but I will be glad to learn other strategies because as you know teaching is vast and it is also better, and it is better to apply new methods as teaching evolve over the years." [**Erika**] "Thinking about these eleven pupils who were struggling to read and understand how to solve problems. I need to think further of how I can help them if I can maybe talk it though with my **colleagues** and do personal research to help them better." [**Beatrix**] "It has helped me to understand that teaching has lots of aspects, and you must be very careful when teaching in the class because you might think that you are right, but you are not right, and you but you are wrong, and you must be also like I have said before be a good listener, because sometimes you learn from other **colleagues** and at times also you learn with the children." [**Charlotte**] "When I gave them more difficult problems some of them had difficulty to make pictorial representation. In my head when I was doing my reflective journal, I say that rather than using this in p2 or p3, like lower classes where they have smaller number of problems to work with, But, then the second time I used it in class I realised that there are also ways of using it when it comes to bigger numbers. So, we tried to talk about it in the class. They liked it. We did group work again. I gave them counters and things like that. Some of them represented it like ratio. Like if I say 150 flowers, they put flowers as 150 and then they drew their own illustration that comes into their mind. This is where I realised that some of them have grasped this concept, and they have actually manipulated it in their own way. So I showed them both concepts, the PIES and the one that we normally use, and then I told them to choose the one that they are more comfortable with." [**Azuza**]
Verbal persuasion	• Self-talk • Mentor teachers • Encouragement	"ya, because when you teach a lesson and then you reflect on it and you say ah, maybe I should have considered other things for teaching that, for example going to the other teacher. We got feedback from the other teachers who previously taught the pupils. And sometimes we go briefly because there is so much and then along the way we tend to go back to the teacher to get more information. The previous teacher gives you a feedback on the pupils they have taught. **You discuss with the teacher things that you are not sure. For example, I made a mistake on this, any idea.** These come in when writing the reflective journal, because when you realise what you have done, you say do I know enough about that what the other teachers would have done. Even if not formally, when you come across certain things or in team planning you always ask for these things." [**Vignette**] "The PD session has helped in my teaching because now I am able to know which strategy to use with which pupils, if they understand and how I can tackle them. Like I said, sir Jemmy

		was my maths teacher and at that time it was NIE." [**Libby**] "I have been in the profession for about seventeen years now. Erm, the profession is quite challenging depending on the group of pupils that you are having, but er, but if you are getting much supports from parents, from management, erm, this makes me stay in the profession, and I am trying to adapt to the new changes brought up by the ministry of education." [**Tilly**]
Physiological responses	• Classroom stress • Fear of failure • Anxiety	"It depends how you felt that day. For example, I did not do the mental activity because I was angry. I did not conclude the lesson because the pupils were making noise. You as a person you will need to reflect. The problem will not always be the pupils. It could be from both sides. You have to deeply reflect where the real problem is. As a teacher I can say that today I did not talk to that pupil, this one did not understand. When I go home, I say how do I get this one to get this part? **I feel bad when a pupil cannot do something even if it is a low ability pupil.** I have to find a way to get him to work on one or two." [**Bryony**] "At first, I **felt extremely angry** because the pupils had forgotten the units, tens and hundreds plus their quantity. However, after several examples and group work, the pupils were able to grasp the concept. Hence, they said they knew it because they had done it before but forgotten it. Thus, this made me realise that every day I have to go over one topic just to refresh the pupils' mind. As a result, soon as they were able to understand the concepts some pupils were excited and unable to concentrate on the task at hand." [**Zara**] "I was feeling really discouraged, and despite making much effort for these kids, they took no interest in their studies. Despite asking them to go through their maths tables several time, some pupils could not even perform the simplest multiplication problem. But somewhere I did get **angry with myself** as after the class I have been thinking that I must had gone through a diagnostic test with these pupils first and then start with percentage, but however. I also felt if I have to explain everything that was done in P5, how I will complete P6 programme. So, I started asking myself many questions and this was stressing me out." [**Marla**]

APPENDIX 35 - Table 8.2: A Typology of Teachers' Self-efficacy Growth

Self-efficacy sources	Participants with their cluster group label
Mastery experiences	Hana (G3), Harriet (G2), Azuza (G4), Fumi (G2), Karin (G2), Andria (G3), Nadine (G1), Zak (G4)
Vicarious experiences	Erika (G3), Beatrix (G3), Charlotte (G4)
Verbal persuasion	Vignette (G3), Libby (G2), Tilly (G2)
Physiological responses	Bryony (G2), Zara (G4), Marla (G4)

APPENDIX 36 - Table 8.3: Mathematics Teaching Self-efficacy Evidence (RQ3)

Participants	Narratives
Hana agreed that it is now that she understood and has the confidence in dealing with word problems.	"I have seen that I was a pupil in primary, this strategy was not used. Therefore, myself I have missed out on strategies of how to step-by-step formulate a problem and solve it also. Now I have better understood how to formulate a problem. How to better solve it. How to do it step-by-step." [**Interview**]
Zak reported that now he has the ability to help his pupils to be competent at solving arithmetic word problems.	"From this experience I have learnt that my teaching can have a direct impact on the learning of the learners. That I have the ability to help the learners to be competent in solving word problems in maths, considering the PIES mnemonic strategy." **[Reflective Journal]**
Beatrix argued that her reflective journals would record her past classroom successes, and these would support her confidence in overcoming future instructional challenges.	"...It will be there, I will be able to use it, not in my mind, maybe something would escape me from my mind, but it will be there in print. I could go back and say last time and say, ah.., last time I did that it did not work. What can I do to prevent that from happening? From there I could do something to provide pupils or myself with the necessary skills to tackle whatever did not go right or use what went right in my next lesson." [**Interview**]
Zak explicitly stated in his reflective journal that there was improvement in the pupils' understanding.	"There was remarkable improvement in their understanding of the topics. The pupils were able to state each step when doing problem solving and also explained how to place their sum to calculate the answer." **[Reflective Journal]**
Hana explained that the RP treatment has increased her confidence in mathematics, thus self-efficacy.	"It has increased my confidence in maths and also has boosted up myself because I know when I am standing in front of the class I am not just saying anything because I know this can be true or this can be wrong, because I am saying something that this is true. I know that 2 plus 2 is 4, so 4 plus 2 is 6. I know what I am saying, I am not just saying anything out of the blue." [**Interview**]
This aspect of trial and error is evidenced from **Azuza**'s words.	"In my head when I was doing my reflective journal, I say that rather than using this in p2 or p3, like lower classes where they have smaller number of problems to work with, but, then the second time I used it in class I realised that there is also ways of using it when it comes to bigger numbers. So, we tried to talk about it in the class. They liked it. We did group work again. I gave them counters and things like that. Some of them represented it like ratio. Like if I say 150 flowers, they put flowers as 150 and then they drew their own illustration that comes into their mind. This is where I realised that some of them has grasped this concept, and they have actually manipulated it in their own way."[**Interview**]

APPENDIX 37 - Table 7.7: Definition and examples of the MKT sub-domains

Sub-domains (*Deductive codes*)	Definition	Classroom Examples
KCT	**Knowledge of content and teaching:** A combined knowledge of student, teaching and mathematics.	Organising teaching activities that will take the student deeper in the learning content.
KCS	**Knowledge of content and students:** A combination knowledge of student, learning and mathematics. Expectations and predictions of students possible answers or thinking.	Foretell or anticipate mathematical tasks that will challenge the students.
Knowledge of curriculum	**Knowledge of curriculum**: Showing familiarity with the curriculum content and strands pertaining to the topics being taught.	Plan daily lessons based on the knowledge of how the curriculum is organised.
SCK	**Specialized Content Knowledge**: Mathematical knowledge that is unique to teaching	Selecting, designing and unpacking mathematical tasks and concepts for students.
CCK	**Common Content Knowledge**: This is a type of teacher knowledge that is not unique to teachers. Non-mathematics teachers can have this type of knowledge as well.	This type of knowledge would be to solve a mathematics problem correctly, as well as being able to identify correct answers given by students.
Improvement in teacher knowledge (*inductive code*)	Teachers making small discoveries while teaching word problem solving skills.	Better understand how to formulate a problem.

APPENDIX 38 - List of Achievements

External Examiner Role

University of the West of Scotland and University of Seychelles (Partnership) - Masters in Business Administration

Supervisor Role

University of Mauritius and University of Seychelles (Partnership) - Master of Educational Leadership