Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.

by

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UNIVERSITY OF PRETORIA

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Declaration

I declare that the dissertation/thesis, which I hereby submit for the degree **PHILOSOPHIAE DOCTOR** at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Dedication

I dedicate this research to my late father Caswell Mxolisi Thobela who did not only uphold the power of education on his children as a baton to run the race of life, but also as a significant tool to make a difference in other people's life.

I also dedicate this research to my mother Nombusiso Octavia Thobela (uka Magaduzela) who, against all odds, supported me throughout my education journey.

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Abstract

Lesson Study (LS), a collaborative practice-embedded teacher development model that originated in Japan, is used globally to foster teacher learning and learners' mathematical thinking. One of the important attributes of LS is conducting the study of curriculum materials (*kyozai-kenkyu in Japanese*), which includes textbooks. This qualitative case study explores teacher engagement with textbooks during collaborative lesson planning, and lesson presentation and observation stages of the Lesson Study cycle in South Africa. The study aims to answer the primary research question: How do Grade 6 mathematics teachers engage with textbooks during the Lesson Study session? Two theoretical lenses were used to gain insights into this study: modes of teacher-text engagement with the textbook advocated by Remillard (2005) and Brown (2011), and Mathematics Knowledge for Teaching (MKT) espoused by Ball et al., (2008). Data were collected using observation and unstructured interviews. Findings revealed that although teacher-text engagement is predominantly with fidelity, they (the teachers) gained more insights into mathematics content and pedagogical skills as well as informed instructional decision-making. However, it was also revealed that the mathematics textbooks (especially the teachers' guides) teachers used in this study do not adequately support teachers. To this effect, I propose the framework for conceptualisation of textbooks for consideration by policymakers, textbook authors, and publishers.

Proposed key words: Lesson Study, mathematics textbooks, intended curriculum, implemented curriculum, curriculum materials

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To whom it may concern

This is to certify that the Doctoral Thesis: Mathematics Teachers' Engagement with Textbooks: The Affordances of Lesson Study written by Nomvuyo Maureen Thobela has been edited by me for language.

Please contact me should you require any further information.

Kind Regards

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List of abbreviations

ANA	Annual National Assessment
ASEI	Activity Student-centred Experiment and Improvisation
ATP	Annual Teaching Plan
CAPS	Curriculum and Assessment Policy Statement
CCK	Common Content Knowledge
CCS	Core Curriculum Standards
CCSSM	Common Core State Standards for Mathematics
CLR	Collaborative Lesson Research
CM	Classroom Mathematics
CMC	Circuit Management Centre
CPD	Continuous Professional Development
CPTP	Continuous Professional Teacher Development
DBE	Department of Basic Education
DEST	District Education Support Team
DM	Didactics of Mathematics
DTDC	District Teacher Development Centre
ECM	Educative Curriculum Material
EDA	Exploratory Data Analysis
EDM	Elemente der Mathematik
EF	Educative Feature
HCK	Horizon Content knowledge
HOTS	Higher Order Thinking Skills
IP	Intermediate Phase
IPO	Input, Process and, Output
JICA	Japan International Cooperation Agency
JLS	Japanese Lesson Study
KCC	Knowledge of Content and Curriculum
KCS	Knowledge of Content and Student
KCT	Knowledge of Content and Teaching
KO	knowledgeable Other
KZN	KwaZulu-Natal
LS	Lesson Study
MDoE	Mpumalanga Department of Education
MKT	Mathematics Knowledge for Teaching
MOE	Ministry of Education
MPRA	Model of Pedagogical Reasoning and Action
MSMT	Middle School Mathematics Teacher
MSSI	Mpumalanga Secondary School Initiative

NCS	National Curriculum Statement
NCTM	National Council of Teachers of Mathematics
NPA	National Protocol on Assessment
PCK	Pedagogical Content Knowledge
PD	Professional Development
PDC	Pedagogical Design Capacity
PDSI	Plan, Do, See and, Improve
PUCV	Pontifical Catholic University of Valparaiso
RQ	Research Question
SA	South Africa
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Education Quality
SALS	South African Lesson Study
SCK	Specialised Content knowledge
SES	Socio-economic settings
SMK	Subject Matter Knowledge
SMT	School Management Team
TA	Thematic Analysis
TIMSS	Trends in International Mathematics and Science Study
TTP	Teaching Trough Problem-solving
TTTL	Textbook, Teacher guide, Teacher, and Learner
UK	United Kingdom
UP	University of Pretoria
US	United States
WALS	World Association of Lesson Studies

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CHAPTER 1: INTRODUCTION

1.1 Background and Introduction

In South Africa, the *National Curriculum Statement (NCS) Grades R-12* is the curriculum policy statement for teaching and learning in schools (DBE, 2011). It was last revised in 2011 and released to the schools for implementation in 2012. This curriculum review was informed by the educational inequalities and imbalances that had been created by the pre-democratic apartheid government (Maharajh, Nkosi & Mkhize, 2016). The NCS is constituted by the: (a) *Curriculum and Assessment Policy Statements* (CAPS) which aim to guide teachers on what to teach, when to teach and how to assess; (b) *National policy pertaining to the programme and promotion requirements* of the *NSC Grades R-12* which outlines the number of subjects to be offered by learners per grade and the minimum promotion requirements to be obtained, and (c) *National Protocol for Assessment Grades R-12* which standardises the recording and reporting processes. For this study, I predominantly focus on CAPS, the component of NCS Grades R-12 that deals with subject content and assessment, and often refer to it as the '(mathematics) curriculum'.

Textbooks, the important aspect of the curriculum, are a fundamental resource that shapes the way teachers teach mathematics (Kojander & Lovric, 2009). Gravemeijer (2014) claims that positive change in mathematics teaching solely depends on curriculum materials such as textbooks. Important as they are perceived to be, teachers tend to engage with or use them in different ways that may enhance or constrain the effective teaching and learning of mathematics (Remillard, 2005, Brown, 2011 & Lester, 2007). In South African, there is no prescribed textbook for mathematics, instead teachers may use as many textbooks as they deem necessary provided that they are approved by the Department of Basic Education as being CAPS compliant. However, being approved by the relevant education department does not guarantee that mathematics teachers will use them effectively to foster effective learning. Given this scenario, understanding how teachers engage with textbooks when planning and teaching mathematics lessons is important to shape how they (textbooks) ought to be conceptualised.

One way of exploring teacher engagement with textbooks is through Lesson Study – a teacher development model that promotes teacher learning through collaboration. Although I pay more attention to issues pertaining to Lesson Study in the next chapter, in

South Africa its cycle consists of five stages: diagnostic assessment, collaborative lesson planning, lesson presentation and observation, reflection and lesson improvement. Out of these five stages teacher engagement with and use of textbooks feature quite prominently in the second stage (*collaborative lesson planning*) and the third stage (*lesson presentation and observation*). The two stages, therefore, lend themselves well for exploring how mathematics teachers engage with textbooks during planning and during teaching.

1.2 Problem statement

South Africa (SA) has continuously demonstrated learner underperformance in mathematics in International Studies such as Trends in International Mathematics and Science Study (TIMSS) (Mullis, Martin, Foy & Arora, 2012), and in Southern and Eastern African Consortium for Monitoring Education Quality (SACMEQ). According to Venkat and Spaull (2015), SACMEQ 2007 results of mathematics teachers' data that was tested on 401 Grade 6 mathematics teachers from primary schools in SA revealed that 79% (about 317 mathematics teachers) demonstrated content knowledge levels that were unacceptably low. On the contrary, Spaull (2013) reported that although there has been an increase in the number of qualified South African teachers since 1994, teacher qualification does not match learner performance (quality of results).

While teachers' content knowledge on its own may not be sufficient for productive teaching, it is, however, the foundation of all types of teacher knowledge base needed for effective pedagogy (Taylor, 2019). On the other hand, data obtained from the SACMEQ 2007 findings also revealed that, Grade 6 and Grade 7 mathematics teachers in South Africa have low levels of subject matter knowledge (Venkant, & Spaull, 2015). From experience, teachers normally select tasks from the textbook during lesson preparation which they are going to present in class, some teach following the textbook (page-by-page), they use worked examples to enhance their understanding of the concept, draw up worksheets and some also use it to give learners homework. So, teaching of mathematics is "lost" without a textbook.

TIMSS 2019 revealed that South African learners' performance is directly impacted by the learners' inability to apply knowledge and understanding in a variety of context and explain reasoning. According to TIMSS' 2019 findings, 60% of mathematics teachers have a mathematics specialisation in their qualification with significant years of

experience in teaching mathematics and these teachers taught two thirds of the learner population. This means, South African teachers are adequately qualified to teach mathematics but learner performance rests way below the benchmark indicating lack of some basic mathematics knowledge. As a result, Spaull (2011) argues that the ability to teach learners effectively does not rest much on teachers' knowledge of the content but on the ability to be able to transmit the knowledge to learners. Therefore, teaching in the high socio-economic setting (SES) countries is more innovative, adaptive, and dynamic than the low SES countries (Spaul, 2011). Boaler and Stapes (2008) assert that teachers need to be professionally developed to uphold the level of cognitive demand needed for meaningful teaching.

Furthermore, according to TIMSS' 2019 findings, the South African assessment framework- National Protocol on Assessment (NPA) places more emphasis on the skills of knowing and solving routine problems and limited emphasis on application and reasoning skills. Although this study is not about assessment, the NPA and CAPS are two of the three documents that constitute the South African National Curriculum Statement (NCS). Therefore, I assert that the kind of learner envisaged by the curriculum defined in the CAPS is impacted by the NPA and in turn impacts the textbook activities. This is evident in the weighting of cognitive levels in the CAPS document, knowledge level (± 25%), routine procedures (± 45%), complex procedures/application (± 20%) and problem solving/reasoning (± 10%). Therefore, ± 70% of the work is on knowledge and comprehension level according to Bloom's taxonomy and ± 30% of the work is on application, analysis, synthesis, and evaluation. On the contrary, the weighting of cognitive demand of tasks in TIMSS (2015) is 40% knowledge, 40% application and 20% reasoning (Thomson, Wernert, O' Grady & Rodrigues, 2015). Therefore, I argue that one of the contributing factors to South Africa performing below average on TIMSS could be based on the way tasks are pitched in the textbooks as per the NPA. This means the NPA may need to be revisited and weighting of cognitive levels adjusted, textbooks aligned to the adjustment for teachers to teach the competent value of HOTS from the textbook.

Fautley and Savage (2013) contend that effective teaching results from effective lesson planning. An effective lesson plan addresses the needs of the learner (Milkova, 2012). Therefore, the question is: how teachers engage with the textbook as they plan and present lessons, since textbooks are said to be the fundamental resource that shapes

their teaching. Different scholars have come up with different modes of teacher-text engagement. However, Stein, Remillard, and Smith (2007) contend that teachers with significant content gaps tend to be *textbook bound*, that is, teachers predominantly transmit knowledge as it is from the textbook. On the contrary, Remillard (2005) stresses that teachers should not only be the transmitters of knowledge, but they should also be the designers of knowledge, a portfolio according to Remillard (2005) that requires them to be mathematically fluent. But, given the background of a South African teacher informed by SACMEQ 2007 results discussed above, are textbooks enabling teachers to be mathematically fluent and therefore designers of knowledge? This study seeks to explore teacher-text engagement relationship in the context of Lesson Study.

1.3 Purpose of the study

According to Huang and Shimizu (2016), teacher engagement with and study of curriculum materials (*kyozai-kenkyu)* is the most important part of lesson planning in the Lesson Study (LS) cycle. The purpose of this study is two-pronged: firstly, to explore teachers' engagement with Grade 6 mathematics teaching and learning materials (*kyozai-kenkyu*), specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the LS cycle. Secondly, by engaging with textbooks, to establish teachers' awareness of coherence between the intended curriculum and implemented curriculum as presented in the CAPS and the textbooks respectively. These two purposes were achieved by exploring: the contribution of mathematics textbooks to teachers' understanding of patterns; the use of mathematics textbook as informants for teachers' instructional decision-making; the extent to which teachers' use of textbooks elicits awareness of the coherence between policy and implemented curriculum and teachers' use of textbooks as they present lessons. Due to the vastness of the Grade 6 mathematics curriculum, the topic *Numeric and Geometric patterns* was explored for the aforementioned purposes. The choice of *Numeric and Geometric patterns* was informed by the revelation in the Annual National Assessment (ANA) Diagnostic report (DBE, 2014) that learners lack the requisite knowledge and skills to solve problems involving this topic.

1.4 Rationale and contribution to the study

The view that textbooks are the most used didactic tool in the classroom is generally uncontested (Kojander & Lovric, 2009). Textbooks have the potential to shape classroom

interaction between the teacher and the learner (Remillard & Heck, 2014). The manner in which teachers use and learn from curriculum materials such as textbooks depends on three components: the reader (the teacher), the material (textbooks) and the context (Lesson Study) (Gueudet, Pepin & Trouche, 2012). Given the key attributes of Lesson Study such as teacher learning and learners' mathematical thinking, it is not surprising that a high premium is placed on the act of studying instructional materials (kyozai-kenkyu) which includes textbooks. Through *kyozai-kenkyu*, teachers are expected to engage in an intensive study of materials to gain insights into content and pedagogical issues underpinning the topic to be taught (Doig, Groves & Fujii, 2011). The central feature to teacher education and professional development is the curriculum materials including textbooks and teacher interaction with them (Gueudet et al., 2012). So, the benefits that teachers can derive from the textbooks during *kyozai-kenkyu* are as good as how teachers engage with and use textbooks. For instance, if teachers engage with textbooks with fidelity to the extent that they are blindly loyal to the textbook, they are likely to take instructional decisions that do not benefit their learners. In addition, my view is that textbooks ought to be conceptualised and written in an accessible manner that fosters teacher engagement with textbooks. Exploring teacher engagement with textbooks, which is the purpose of my study, is important research undertaking to gain further insights into how teachers learn (develop their content knowledge and pedagogical skills).

The contribution of this study is two-fold: firstly, it enlightens policy-makers, researchers, textbooks writers and textbook publishers on how mathematics teachers engage with textbooks, and how mathematics textbooks should be conceptualised; secondly, based on the findings, it proposes a framework for textbook writing to policy-makers and textbooks writers/publishers for their consideration when conceptualising textbooks to foster effective teacher engagement with textbooks during kyozai-kenkyu within and outside the Lesson Study context.

1.5 Research questions

The primary research question for this study is: How do Grade 6 mathematics teachers engage with textbooks during the Lesson Study session?

The primary research question was answered through the following secondary research questions:

a) How do mathematics textbooks contribute to teachers' understanding of *patterns*?
b) How do teachers' use of mathematics textbook activities inform instructional decision-making during collaborative lesson planning?
c) To what extent is teacher engagement with textbook eliciting their awareness of coherence between the intended (CAPS) and implemented curriculum (textbooks)?
d) How do teachers use textbooks during lesson presentation?

1.6 Literature review

Although I deal extensively with the relevant literature in the next two chapters, in this section, I briefly reviewed literature on the definition and the conceptualisation of Lesson Study, how LS evolved over time, the role textbooks play in the teaching of mathematics and, the theoretical perspective of teacher engagement with textbooks in the context of Lesson Study.

Fernandez (2002) asserts that Lesson Study (LS) literally translates to *Jugyokenkyu* in Japanese where "*jugyo*" means lesson and "*kenkyu*" means study or research. However, he argues that this definition is limiting because LS is more than just the study of lessons. Lesson Study is a Japanese model used to improve the quality of teaching and learning and is a collaborative teacher-based developmental approach (Fernandez, & Yoshida, 2012). The Japanese LS cycle has four stages, namely, (1) study the curriculum and formulate goals, (2) plan, (3) conduct research lesson (4) reflect (Lim-Ratnam, 2013).

According to Stigler and Hiebert (1997), the attraction by other countries to LS emerged from the video component of the Trends in International Mathematics and Science Studies (TIMSS) because of the worldwide interest in teacher quality. Stigler and Herbert (2016) stress that Lesson Study is steadily "diffusing" around the globe but also highlights that its implementation is guided by the context of the country or culture.

There has been a subsequent number of international workshops and conferences around the world for different countries to share their own experiences about the implementation of LS (Murata, 2011). Lewis and Lee (2017) used the World Association of Lesson Study (WALS) conferences to investigate the global spread of LS. They argue that in the first WALS which was held in 2007, 15 countries attended with 311 participants where most of the participants were from Hong Kong and Singapore. As the years

progressed, the number of participants increased at these conferences due to the involvement of the Japanese International Cooperation Agency (JICA) who introduced LS to several countries. The South African adaptation and contextualisation of LS is informed by five stages as outlined by Sekao and Engelbrecht (2021). SA's first stage of the LS focuses on diagnostic assessment and analysis and then followed by the four steps of the Japanese model (Sekao & Engelbrecht, 2021). However, the concept of *kyozai-kenkyu,* which is the study of curriculum materials including textbooks, is located in the Stage 2: Collaborative lesson planning in the South African LS model. In Stage 3, as one teacher presents the lesson, the rest of the teachers observe the presentation of the lesson and, when it is time for classwork, teachers walk around to view what learners write to validate their (the teachers') data.

Remillard (2005) defines a textbook as an artefact that serves as a conveyor of the curriculum, it mediates the intended curriculum and the implemented curriculum. According to Kajander and Lovric (2009), a textbook is a fundamental resource that shapes the way teachers teach and learn mathematics. Herbel-Eisenmann (2007) examined the "voice" of a mathematics textbook from intended curriculum to written curriculum. Findings revealed that the task of developing textbooks to be more learner centred and have activities at a higher cognitive level was not found easy for the authors and as a result, there was a mismatch in the way the content was presented from the intended curriculum to the written curriculum. That means, the set standards were not met.

Textbooks have the most influence on teachers' instructional method regarding enacting the curriculum (Polikoff, 2015). Polikoff (2015) investigated how well aligned mathematics textbooks are to common core standards and findings depicted that there was substantial misalignment of textbooks to the set standards. Therefore, the kind of learner envisaged by policy may be deformed if the intended curriculum is misrepresented in the textbooks leading to gaps in the attained curriculum. Hadar (2017) asserts that learners exposed to textbook activities demanding different cognitive levels have a better understanding of the mathematics content compared to a learner who is exposed to textbook activities that are standard and have not incorporated different cognitive levels. Therefore, the indicator of the effective implementation of the intended curriculum is the textbook and as such, there needs to be a tight bond between the two.

According to Stein, Remillard and Smith (2007), there are several factors that contribute to how teachers engage with the textbooks, such as, classroom control and management; teachers' professional identity; teachers' mathematical content knowledge and teachers' perception of a textbook. Herbel-Eisenmann and Wagner (2007) argue that it is imperative to 'interrogate' the curriculum material to investigate teachers' use of it. My study includes *kyozai-kenyu* (study of curriculum materials - textbooks) and according to Huang and Shimizu (2016), *kyozai-kenkyu* is the most important part of lesson planning stage within the LS cycle.

Lester (2007) categorises teachers' approaches to curriculum use in terms of content coverage, components of the curriculum and program philosophy. Teachers tend to be more concerned about curriculum coverage and less concerned about pedagogical approaches that enhance meaningful learning (Lester, 2007). Brown (2011) argues that there are three ways in which teachers use the curriculum, *inter alia*, by offloading (delivering the contents of the textbook as it is); by adapting (adapting activities and suggested teaching strategies to suit teachers' preference and the recipients of knowledge) and by improvising (substantial deviation from the curriculum and ability to create one's own tasks). Furthermore, Remillard (2005) agrees by distinguishing between three modes of teacher engagement with the textbook – (1) as following or subverting – which is aligned to offloading above; (2) as interpretation - which is aligned to adapting above and (3) as participating with – which is aligned to improvising. I used Brown (2011) and Remillard's (2005) conceptualisation of how teachers engage with the textbook to guide teacher engagement with the textbook in this study. Although Brown's (2011) and Remillard (2002) perspectives of teacher engagement with textbooks is not in the context of LS, they still provide relevant and appropriate guidance on how teachers engage with textbooks – after all *kyozai-kenkyu* involves engaging with and studying textbooks.

1.7 Concept clarification

Intended curriculum: the overt curriculum that is reflected in policy which schools and other relevant educational institutions are set to accomplish (Valverde, Bianchi, Wolfe, Schmidt & Houang, 2002).

Implemented curriculum: the actual teaching and learning activities, wherein its content originates from policy, that are selected by teachers as they interact with curriculum

materials such as textbooks in designing lesson plans. It is the *teacher-intended curriculum* (Remillard & Heck, 2014).

Enacted curriculum: the unscripted curriculum that emerge through interaction between the teacher and the learner focussing on instructional material(s) and the teacher's lesson objective (Remillard & Heck, 2014).

Curriculum materials: are educational resources that are used by the teacher when developing a lesson or in the classroom to guide their teaching including textbooks, supplementary units, or modules (Remillard, Harris & Agodini, 2014). In relation to this study, curriculum materials are only limited to textbooks.

Policy envisaged learner: a critical thinker with collaborative, innovative and communicative skills that foster deep conceptual mathematical understanding of mathematical ideas (DBE, 2011).

1.8 Theoretical framework

This study is informed by two theoretical lenses namely, the Mathematics Knowledge for Teaching (MKT) framework as well as Remillard (2005) and Brown's (2011) modes of engagement with curriculum materials. Although Remillard (2005) and Brown (2011) use the over-arching term 'curriculum materials' to include, inter alia, textbooks, I am, in this study, exclusively focusing on one form of curriculum material, the textbook. In addition, given that teacher engagement with textbooks takes place within the confines of teaching practice where content knowledge and pedagogical skills are required and/or further developed, the MKT framework is the main theoretical perspective that undergirds the study. The repertoire or bank of knowledge that mathematics teachers need to have to effect teaching and learning is referred to as the *Mathematics Knowledge for Teaching* (Ball et al., 2008). In other words, teacher engagement with textbooks does not take place in a vacuum, rather it is driven by content knowledge and pedagogical skills, and by reciprocity teachers tend to strengthen their content knowledge and pedagogical skills as they engage with textbooks. The MKT framework assisted me to respond to all four research questions regarding teachers' knowledge base, while Remillard and Brown's modes of teacher engagement with textbooks assisted me to understand how teachers engage with textbooks during collaborative lesson planning and lesson presentation.

1.9 Research methodology

This study adopted the interpretivist paradigm and was guided by Saunders et al.'s (2009) research onion. Creswell (2014) argues that constructivists/interpretivism believe that the world is socially constructed (ontology); the researcher relies on the participants' views of the researched phenomenon while recognising the role of his/her background and experience. Accordingly, the ontological and epistemological implications of interpretivist paradigm lend themselves to qualitative methodology. Using the interpretivist paradigm, I was able to get a deeper insight of how teachers engage with textbooks in the context of LS.

The methodological approach adopted in this study was qualitative. In line with the interpretivist paradigm, the qualitative approach enabled me to observe how teachers engage with textbooks *in situ* in the context of LS. To deeply understand some tacit actions and make meaning of unclear utterances, observations were corroborated by interviews where necessary. Although I predominantly used an inductive approach in this study, I used both inductive and deductive approaches. Regarding the inductive approach, I had to immerse myself in the data collection process to feel the pulse of the data and gain deep understanding of how teachers engaged with textbooks during lesson planning and lesson presentation (Leavy, 2017). Regarding the deductive approach, I used a priori knowledge gleaned from literature on how teachers engage with textbooks.

An exploratory case study design afforded me an opportunity to gain understanding of teacher engagement with textbooks in their natural setting – the classroom (Yin, 2012). This attribute of case study resonates with the ontological and epistemological assumptions of the interpretivist paradigm. Schools whose Grade 6 teachers had been participating in the Lesson Study prior to this study and were in close proximity to my work location were chosen to participate in the study. Data were collected through observations and interviews.

1.10 Quality criteria to ensure trustworthiness

The quality criteria to ensure trustworthiness of the study include credibility, transferability, confirmability, and dependability. Each one of these criteria is clarified next:

- Credibility - Shenton (2004) highlights that this criterion is used to ascertain whether there is a "fit" between the participants' views and the way the results and findings are presented by the researcher. This study is credible because the participants' responses were used selectively to substantiate findings during analysis. The data collection techniques were triangulated in this study to validate collected data.
- Transferability - Shenton (2004) refers to this criterion as the degree of similarity between two or more similar contexts.
- Confirmability - Korstjens & Moser (2018) highlight that this criterion is concerned about the degree to which the findings of the study can be confirmed by other researchers for the same enquiry under the same settings. Therefore, an audit trail could be done since all documents pertaining to the study are available. Issues of member checking were adhered to ensure confirmability.
- Dependability – Connelly (2016) attests that this criterion would be realised if the same results are obtained using the same instruments on the same audience. In this study, dependability was ensured by clearly describing the research design, data collection plan and techniques and how data was analysed. Transcripts were also chronologically filed for easy access to anyone that may have an interest.

1.11 Ethical consideration

The following ethical practices were observed:

- Voluntary participation: participants were not coerced into taking part in the study. They were required to give informed consent by signing the consent forms to be part of the study as participants.
- Confidentiality: although I knew the participants' names and their respective schools, their identity remained confidential and was not revealed in the study.
- Anonymity: pseudonyms were used for the different titles of textbooks and the participants' names to conceal their identity in the entire study. Even though learners were indirectly involved in the study because they formed the audience for lesson presentation, their names or pseudonyms were irrelevant in this study as they were not the focus of the study.
- Justice: fair and equal treatment was given to the participants by the researcher.

1.12 Researcher's background and motivation to undertake the current study

I am a mathematics subject advisor based in the education district in a province in South Africa. I was introduced to LS through the country-focused training offered by Naruto University in Japan, under the auspices of Japan International Cooperation Agency (JICA). My core responsibility at my district is to support mathematics teachers (Grades 4 to 9) on mathematics content and teaching methodology. My experience during school support visits is that teachers tend to rely on textbooks for mathematics teaching and assessment. When it comes to assessment, whether formal or informal, some teachers tend to photocopy assessment activities from the textbook and administer them to learners. One other resource that mathematics teachers are given by the government to use at schools are the learners' workbooks which have activities for learners to complete. However, unlike textbooks which have solutions/answers to the activities/questions, workbooks do not have the answers. Some teachers, therefore, tend to not use the workbooks to expected levels citing lack of solutions/answers to guide them. Generally, dependency on textbooks and workbooks deprive teacher learning, thereby stifles sustainable professional development.

It is also worth noting that teachers in the Intermediate Phase (grades 4-6) do not specialize in any subject, they are generalists. Normally, when conducting workshops, a common practice is to choose one grade within the Intermediate Phase, predominantly Grade 6, to limit the number of teachers leaving the school to attend the workshop. Teachers would then be expected to cascade the information that was shared at the workshops when they get back to their respective schools. However, in my district, whenever mathematics workshops are conducted their duration is normally three hours because they (the workshops) can only start at mid-day, so that teachers can first start at school before coming to the workshop to avoid compromising the teaching time. Since my district is a rural district, this poses a lot of challenges because other teachers are not able to start at school as they would not have transport to take them to the workshop mid-day. As a result, this form of teacher in-service professional development renders itself ineffective and unsustainable.

Given this background of mathematics teacher-text relationship and professional development training sessions, the implementation of Lesson Study aroused an interest

in me of wanting to investigate how grade 6 mathematics teachers engage with the textbooks. Specifically, the practice of studying or investigating curriculum materials such as textbooks, *kyozai-kenkyu* in Japanese, is engrained in Lesson Study as an important trait of collaborative lesson planning. I was, therefore, intrigued by *kyozai-kenkyu*, and it ignited interest in me to gain insights into teachers' utilization of textbooks during planning and presentation of lessons.

1.13 Chapter outline

This research report is structured into six chapters. A brief description of what each chapter entails is presented in the next sections:

Chapter 1: Introduction

In Chapter 1, I presented a summary of the study which included, inter alia, the background and introduction, literature review, and theoretical framework.

Chapter 2: Lesson Study as a teacher development approach

Since Lesson Study is the context within which this study is situated, in Chapter 2, I provided a comprehensive account of Lesson Study as a teacher development approach. This includes its origin and globalisation. I chose a few countries to illustrate how Lesson Study attracted global interest and was adapted or contextualised for implementation in these countries. My illustrations culminated into a detailed explication of the Lesson Study cycle implemented in South Africa where my study is situated. I further highlighted the benefits and the conceptual anomalies that often emerge from the globalisation of LS.

Chapter 3: Theoretical framework and literature review

In Chapter 3, I first presented and explicated the theoretical lenses that frame this study, i.e. the MKT framework and the modes of teacher engagement with the textbook espoused by Remillard (2005) and Brown (2011). Thereafter, I discuss the reviewed and synthesised relevant literature to gain in-depth understanding of the issues pertaining to teacher engagement with textbooks. In addition, the literature helped me to make sense of the findings of this study and strengthen my discussions.

Chapter 4: Research methodology

In Chapter 4, I presented the research methodology chosen for this study guided by Saunders et al.'s (2009) research onion. The issues addressed in this chapter include philosophical assumptions, research approach, research procedures, sampling, data collection and analysis.

Chapter 5: Presentation of findings

In Chapter 5, I presented the findings guided by the themes that emerged from data analysis.

Chapter 6: Discussion of findings

In Chapter 6, I discussed the findings presented in Chapter 5. In the discussion I highlight the possible implications of the findings for the teaching and learning of mathematics in primary schools. To do this meaningfully, I draw from the reviewed literature. In addition, I reflect on the affordances of the two theoretical lenses which undergird the study. In other words, how did the theoretical lenses assist me to gain insights into the title under investigation, and to respond to the research questions. As a contribution to the body of academic knowledge and for policy development, I proposed a framework to guide textbook conceptualisation and development. I then conclude by presenting the limitations of this study, making recommendations for further research.

CHAPTER 2: LESSON STUDY AS A TEACHER DEVELOPMENT APPROACH

2.1 Introduction

Since I sought to explore how Grade 6 mathematics teachers engage with textbooks in the Lesson Study (LS) context, it is essential to familiarise the reader with the concept of LS which constitutes the context of this study. In this chapter, therefore, I focused broadly and exclusively on detailing origin and globalisation of Lesson Study as a teacher development model. Firstly, I discuss the origin of LS and global evolution over the years using LS models from selected countries to illustrate how it evolved. Secondly, I discuss the traditional cyclic process of the Japanese LS since LS originated in Japan. Thirdly, I discuss the evolution and variations of LS in some of the respective countries that have implemented LS. It should, however, be noted that by using the selected countries as illustrations does not imply changing the focus of the study to be comparative but rather demonstrating the global evolution of LS in different contexts. I discuss the impact LS has had on teaching and learning for both practising and prospective teachers. Fourthly, I orientate the reader to the location of this study within the South African Lesson Study (SALS) context after which I discuss the (mis)conceptions of globalisation of LS. I then discuss the benefits of LS and the challenges that the respective countries may have had in trying to implement LS. Lastly, I conclude the chapter.

2.2 The origin and globalisation of Lesson Study

Hasan et al. (2021) assert that the Japanese phrase for Lesson Study (LS) is *Jugyokenkyu* where "*jugyo*" directly translates to lesson and "*kenkyu*" to study or research. Lesson Study originated in Japan (over a century ago) and is a model of collaboration-based teacher professional development that focusses on improving the quality of teaching and learning in the classroom in elementary schools (Lewis, Perry & Hurd 2009, Yarema, 2010 and Fujii, 2014). However, Watanabe (2019) argues that LS is not only concerned about teachers' professional development, but also plays a crucial role in informing the education system at large about aspects that need to be revised in the curriculum policies after the set number of years but more frequently in the development of the textbooks. According to Murata and Takahashi (2002), LS is a "vehicle" to connect theory (Intended curriculum), research and practice (Implemented curriculum). Lesson Study is 'a systematic investigation of classroom pedagogy

conducted collectively by a group of teachers rather than by individuals, with the aim of improving the quality of teaching and learning' (Tsui & Law, 2007). Evidently, as teachers participate in the Lesson Study process, there is meaningful and deep professional learning taking place (Lewis & Perry, 2014), e.g. learning of content and pedagogy. In fact, Takahashi and McDougal (2016, p. 515) ardently allude to the fact that by engaging in the Lesson Study process teacher "build expertise and learn something new…".

Groves, Doig, Vale and Widjaja (2016) assert that the Japanese Lesson Study (JLS) is a non-funded and non-mandatory professional learning activity that is practised at three levels: the school-based level; the regional level and the national level. However, they contend that the school-based LS is the one that attracted many countries outside Japan, especially at the elementary schools. One distinguishing characteristic between traditional teaching and teaching in the context of LS is that, in the traditional teaching, teaching is teacher-centred, and learners are taught in a manner that is conducive to them passively receiving information from the teacher (Tularam, 2018), whereas, in the context of LS, teaching is done through problem solving and learners are actively involved in solving problems (Fujii, 2018).

2.3 Traditional cyclic process of Japanese Lesson Study

According to Lewis (2009) the school based JLS comprises of four stages: study the curriculum and formulate goals, plan, conduct research lesson and reflect.

Study the curriculum and formulate goals

At this stage, teachers work collaboratively in executing *kyozai-kenkyu* (Seleznyov, 2018). K*yozai* (curriculum materials) and *kenyu (*study or research), is the process of investigating the curriculum to be taught, students, as well as resources to be used prior to lesson enactment (Doig & Groves, 2011). The main activity involved in *kyozai-kenkyu* relates to teachers' mathematical knowledge because they are, *inter alia*, expected to design tasks for classroom lesson(s) often using textbooks as the main resource (Mizoguchi & Shinno, 2019). Doig and Groves (2011) contend that the findings from the post-lesson discussion of the previous cycles could subsequently also be used as one of the resource forms that could be studied to inform the development of the following new research lesson (could be on the same theme) that are taught by a different teacher to a different cohort of learners.

Plan

During the planning stage, teachers have a task to collaboratively develop the *learning proposal - gakushushido-an* (Fujii, 2016, Nishimura, Kobayashi, & Ohta, 2018). According to Doig and Groves (2011), it is possible to explore different or the same subject matter with the same or different *kyozai* respectively. Furthermore, Nishimura, Kobayashi and Ohta (2018) contend that at this stage, the study of the curriculum includes consideration of criteria such as: carefully analysing the topic and aligning it to the lesson objectives; consideration of learners' anticipated responses; analysing and linking the topic to be taught with learners' prior knowledge; being mindful of topics still to be taught; data collection plan, model for learning trajectories; links within the topic itself and a justification of the chosen approach for enactment. In addition, for teachers to select appropriate and informed tasks during lesson planning, more time should be spent on research into the mathematics involved which include investigating a range of instructional materials such as textbooks; curriculum materials; lesson plans and reports from other lesson studies; study of students' existing knowledge and understanding of the concept for them to anticipate students' responses and solutions to the planned tasks (Doig & Groves, 2011).

Fujii (2018) attests that in Japan, teachers teach using a textbook, but they do not teach a textbook. Therefore, textbooks that precisely explicate the teaching methodology are forbidden (Fujii, 2018). The Japanese teachers view themselves as researchers of their own teaching practice more than them being just teachers (Winsløw, Bahn and Rasmussen, 2018). *Koshi* is a person with extensive knowledge of the subject content with its topics and vast experience with collaborative lesson research that, may assist teachers during lesson planning by helping them identify valuable resources for the lesson; instructional examples and may also give feedback on the lesson proposals (Takahashi & McDougal, 2016). Lewis and Takahashi (2013) also attest that there is no formal training for koshi, but through involvement in LS, one may become one. Moreover, while Watanabe, Takahashi, and Yoshida (2008) argue that a well conceptualised *kyozai-kenkyu* guarantees success of LS, Kajander and Lovric (2009) argue that textbooks are a fundamental resource that impact a great deal on how mathematics is taught and learnt to produce well conceptualised lesson(s). On the other hand, Remillard (2018) contends that teachers' pedagogical design capacity (PDC) is crucial in designing a valid and reliable *learning proposal*.

Conduct research lesson

Watanabe, Takahashi, and Yoshida (2008) assert that at this stage, one teacher from the group presents the lesson while the other group members collect data on student learning through observation guided by the *learning proposal* that they had designed. According to Doig and Groves (2011), the process of lesson presentation in LS encapsulates the following:

Hatsumon: The teacher briefly recaps on the previous lesson and then poses a problem for the day.

Kikan-shido: The teacher then allows students to work in groups or individually while she/he does "purposeful scanning".

Neriage: The teacher kneads students' ideas; allow students to compare and refine their solutions assisted by the teachers' probes.

Matome: The teacher sums up the lesson guided by careful review of the students' discussions with an aim of lifting them up to higher levels of understanding. The focus for observers should be on student thinking and learning (Doig & Groves, 2011). Fujii (2016) clarifies these four stages of lesson presentation in mathematics by attaching time that could be spent to address each stage in a lesson. He posits that the *hatsumon* stage could last between 5 - 10 minutes; the *kikan-shido* and the *neriage* stage could last in the range between 10 - 20 minutes; the *matome* stage could last for about 5 minutes.

In addition, chalkboard (*bansho*) is extensively used in the Japanese classrooms during normal classroom discourse, but ironically, modern classroom equipment such as computers, overhead projectors and electronic white board are manufactured in Japan and yet not extra-ordinarily used (Doig & Groves, 2011).

Reflect

According to Doig and Groves (2011), the group of teachers meet to share and discuss the information that was collected from the learners during classroom observation and use it to illuminate student learning and other significant issues in teaching and learning of that particular content. Teachers' own learnings are also shared and collectively these learnings are used to strengthen the lesson plan for the next cycle (Doig & Groves, 2011). The discussions are informed by what was learnt; things that may have emerged and are

worth considering in the enactment of the next lesson and things that need to be improved (Watanabe et al., 2008). During post-lesson discussion, the focus is on the lesson (the teaching) and not the presenter (the teacher) (Fujii, 2016) however, the lesson presenter is afforded an opportunity to speak first by the facilitator of the reflection session who may be the principal of the school or any other teacher or member from within the school (Doig & Groves, 2011). According to Doig and Groves (2011), the presenter is expected to explain to the audience the group's intentions for the lesson and informed by how the lesson had rolled out, highlights the group's impression of the elements of the lesson that were perceived as successful or less successful citing examples from the lesson to support the perception. The rest of the planning team members then explain the rationale for the lesson and how it matched the theme after which the platform is then opened for comments by other observers (if there were any) followed by lastly, the knowledgeable other *(koshi)*.

Evidently, it is imperative to understand explicitly the pedagogical principles and processes that underpin LS before its spread throughout the globe. Doing so will prevent LS outside Japan from being *lethal* to being *local* (Wolthuis, van Veen & de Vries, 2020). How then has LS been contextualised, adapted, and implemented globally? The next sections deal with this question by illustrating with the LS models from different countries.

2.4 Evolution and variations of Lesson Study

According to Stigler and Hiebert (1997), the attraction by other countries to LS informed by the worldwide interest in teacher quality emerged from the video component of the Trends in International Mathematics and Science Studies TIMSS (1995). In the TIMMS video, the teaching methods of the Grade 8 mathematics teachers of Japan, Germany, and the United States (US) were compared and analysed with the aim of ascertaining contributing factors to the Japanese learners scoring way above the scale score in international assessments such as TIMSS. The other area of focus was educational standards, methods of managing individual differences, teachers' lives and working conditions, time spent on practice exercises and application or questions that require learners to be inventive and think on the set topic (Stigler & Hiebert, 2009). Consequently, Stigler and Hiebert (1997) identified a *Teaching gap* (published in 1999 and updated in 2009) which they described as the differences between the pedagogical principles necessary to attain the objectives of the country's set core standards and the actual

teaching methods practiced by teachers in the US. The findings of the study revealed that in Japan, the *Teaching gap* was less evident by a great margin than that in the US. According to Stigler and Hiebert (2009), these findings emanated from the notion that in Japan, the teaching goals matched the learning goals while in the other two countries there was a mismatch between the learning and the teaching goals.

Furthermore, Stigler and Hiebert argued that just one study would not be enough to conclude that the Japanese teaching method accounts for their learners' high academic performance in relation to other countries. Therefore, in 1999 they conducted the same study, but they used high-performing countries as the sample, countries such as the Czech Republic, Hong Kong, The Netherlands, Switzerland, and Japan. They found that in as much as the teaching methods of the respective countries varied, there were common features that fostered a match between teaching goals and learning goals and as they engaged in the *productive struggle*, learners were provoked to think and apply their mind to solve problems. Informed by these findings, Stigler and Hiebert gained interest in how the *Teaching gap* could be reduced in the less-achieving countries and the response pinpointed to the evolving teaching model used in Japan – Lesson Study (*jugyou kenkyu*). Consequently, Stigler and Hiebert (2016) stress that since then, LS steadily "diffused" around the globe but also highlight that its implementation is guided by the context or culture of the country.

The focus on learner conceptual understanding is the key to effective implementation of LS (Ono & Ferreira, 2010). However, Wolthuis, Veen, de Vries and Hubers (2020) argue that during the presentation of the ostensive script of the JLS, it is imperative that its core elements, which they refer to as performatives, and its usefulness is thoroughly discussed and understood by teachers (who are the recipients, practitioners, and implementers) for effective implementation and sustainability of LS outside Japan.

Groves, Doig, Vale and Widjaja (2016) argue that while global countries adopted the JLS model of teacher professional development, certain elements of the JLS cycle were made *a priori* to be adapted. During the process of borrowing the JLS model of teaching and learning to local context, the same model undergoes "transformation from an idea that is global into a practice that is glocal" (Winsløw, Bahn and Rasmussen, 2018). For the purpose of this study, I have chosen to discuss the LS models from practiced in selected developing and developed countries to illustrate the different variations thereof.

2.4.1 Lesson Study in United States of America (USA)

Literature has shown that the LS model implemented in one state in the US may not necessarily be the same as the one implemented in the other (Takahashi & McDougal, 2016). The Mills College LS group (n.d) cycle consists of a hidden Step 0 where the LS team agrees on the schedule and the work process that they are going to follow, i.e., decide on facilitation; adopt an agenda and agree on roles and expectations as the cycle continues. However, they attest that as LS teams become more familiar with LS, this step need not stand on its own, it may be incorporated to Step 1 and that is why it does not show on the cycle. In addition, in Step 2, the Mills College LS group (n.d) contends that the collaborative lesson planning extends to teachers teaching the "mock-lesson", reflecting on it and adapting it before they proceed to Step 3 (teaching and observing the lesson) of the cycle, which is not done in the JLS cycle. Furthermore, of difference to the JLS cycle is that the lesson is continuously improved and re-taught until it satisfies the objectives (Mills College LS group, n.d).

2.4.2 Lesson Study in China

Chinese Lesson Study (CLS) entails the development of public mathematics and exemplary lessons through action education model-*keli* (Huang, & Shimizu, 2016). The action education model focuses on the transformation of the current/existing teaching to policy-based teaching practice (Pang, & Marton, 2017). Gu and Gu (2019) posit that while the CLS consists of 3 phases of teaching practice, i.e., the existing, designing and implementing phase, it also consists of two phases of reflection on rehearsal teaching. The first reflection phase involves identification of the differences between the current/existing teaching practice and the innovative ideas and, the second reflection phase identifies the gap between the innovative plans and the implementation (Gu, & Gu, 2019). Although CLS is embedded on content and methodology with multiple rounds of rehearsal lessons, the contribution of "knowledgeable other" in lesson reflection is also emphasised as in the JLS (Pang, & Marton, 2017). Similar to JLS, in the CLS, teacher group sets consisting of teachers of the same subject and grade sit together and plan a lesson which is later presented by one of them while the rest of the teachers observe it (Pang, & Marton, 2017). After the lesson has been presented, it is reflected upon by the presenter and the rest of the group wherein it (the lesson) is then strengthened, and then taught by a different teacher to a different set of learners (Pang, & Marton, 2017).

According to Pang and Marton (2017), the cycle repeats itself again and the strengthened lesson can be presented by the third teacher. In addition, Pang, and Marton (2017) highlight a distinguishing feature of CLS with respect to other countries by asserting that there are three different types of CLS which are defined by teachers' career stages namely, *report lessons* (for novice teachers); *research lessons* (for experienced teachers) and *demonstration lessons* (for expect teachers). Important to note is that the common feature in all the CLS types is constant collaboration, study, and evaluation of lessons as normal practice through teacher research groups and teachers who apply for promotion are required to present a lesson (Pang, & Marton, 2017).

What is also different from the JLS is the development of the Learning Study consisting of four stages (Pang & Lo, 2012). According to Pang and Marton (2017), Learning Study focuses on the object of learning (concept). Lessons should be preceded by the evaluation of learners' existing or current understanding of the object of learning obtained through tests or interviews and their (learners) understanding should again be measured at the end of the cycle to understand the impact the lesson would have had on them (the learners) (Pang, & Marton, 2017).

2.4.3 Lesson Study in Chile

Chile also adapted the Japanese LS cycle to suit their context in 2006. According to Estrella, Mena-Lorca and Olfos (2018), in the initial stages of LS implementation, officials from Japan would come and teach demonstrative lessons to learners of the selected attached university primary schools. In addition, to cover more ground and make more meaning in terms of mathematics professional development, the Chilean Department of Education in conjunction with the Japanese selected three groups comprising university professors from eleven different universities and two other officials in charge of educational pedagogy to go to Japan (funded by JICA) to learn the Japanese culture of teaching. These delegates were expected to come back and implement LS in their country (Estrella et al., 2018). These two universities had their headquarters located outside the capital and, had an advantage of being the only institutions in the country that offered a master's program in Didactics of Mathematics (DM) at the time of implementation (Estrella et al., 2018). LS was more focussed on the post-graduates with the hope that they would continue implementing it when they get to the field (Estrella et al., 2018). They contend that at the end of the year, the program was evaluated, and

deemed fit for it to continue because the feedback was positive, however, Ministry changed in 2010 and only two out of eleven trained universities in the country continued with the program of which the authors report on the roll out of one university - Pontifical Catholic University of Valparaiso (PUCV). Estrella et al. (2018) posits that at the PUVC they had been using *exploratory data analysis approach* (EDA) - *problem, plan, data, analysis, and conclusions approach* (PPDAC) to teaching, they then infused these teaching approaches within the context of LS to promote them. In addition, the Chile LS cycle has no indication of the use of KO as in the JLS. Estrella, Mena-Lorca and Olfos (2018) attest that implementing LS has not been easy and therefore not many schools are implementing it; however, graduates from the university assist in the spreading of LS when they get to the field.

2.4.4 Lesson Study in UK

In the UK, the LS cycle was also adapted to suit their context. According to Dudley (2014), a complete LS cycle in the UK involves three stages. Dudley (2014) recommends that for the initial implementation of LS, a group of three teachers with varying teaching experience and preferably representing the different intellectual ability of a group of learners in the classroom may be selected. This recommendation may impact positively on the LS process as it may foster an effective and productive *kyozai-kenkyu* and lesson planning (Dudley, 2014). A notable difference to the JLS cycle is that the UK LS cycle has a stage where selected learners are interviewed after lesson presentation and these selected learners are referred to as “case pupils” (Dudley, 2014). One of the selection criteria for the number of “case pupils” according to Dudley (2014) is the number of times that the LS cycle is repeated. For instance, the complete cycle is formed by three repeats, therefore there should be “case pupils” for each repeat and the selection thereof should be informed by learning pace – low, average, high (Dudley, 2014).

All three teachers get a chance to teach and interview learners in the cycle, therefore, different teachers teach different learners the same lesson but, at the second level, the lesson has been refined and even more refined at the third level. According to Dudley (2014), the last stage of the cycle is where the three teachers would sit together and document their experience with an intention to share the findings with the larger population of teachers through demonstration or coaching.

2.4.5 Lesson Study in The Netherlands

The Netherlands is also one of the European countries whose LS adaptation to their context was mostly influenced by both the American (Stepanek, Appel, Leong, Turner Mangan & Mitchell, 2006) and British (Dudley, 2011) adaptation in the sense that it also involves an element of *case pupils* but differs in the number of repeat lessons to complete an LS cycle (Wolthuis, Veen, de Vries, Hubers, 2020). Out of interest however, compared to the Japanese education system, according to Wolthuis et al. (2020), the Dutch version of LS does not have a national curriculum, teachers need to teach towards Core Curriculum Standards (CCS). As a result, the concept of *kyozai-kenyu* in the Netherlands is "loose" (Takahashi and McDougal, 2016). Therefore, in view of the absence of the national curriculum, teachers are advised to review literature and use one anothers' expertise when planning lessons. However, according to Wolthuis et al. (2020), the Dutch LS cycle consists of six stages namely, phase one: picking a research theme entails the following activities: formulation of long-term goals, lesson goals and research goals for learners; phase two: planning of the research lesson including specific, measurable, acceptable, realistic and time-bound goals, choosing *case pupils* and describing anticipated learners' response; phase three: lesson presentation and observation and interviewing of *case pupils*; phase four: the lesson is discussed and reflected upon focussing on the student learning *vis a vis* the research goals, phase five: the lesson is revised and retaught and phase six: reflection on the entire process sharing gains, insight to a broader school community.

2.4.6 Lesson Study in Zambia

The Ministry of Education (MOE) and JICA (2010) outlines Zambia's LS cycle as consisting of eight stages. Likando (2018) asserts that the adaptation of LS in Zambia was informed by the large number of mathematics and science teachers that were underqualified or unqualified to teach the respective subjects. Therefore, the addition of four steps in the Zambian LS cycle as compared to the JLS cycle was meant to assist teachers gain confidence through peer learning on content and pedagogy (Likando, 2018). Baba and Nakai (2011) posit that one other reason for adopting LS in Zambia was to move from the teacher-centred approach to teaching to a learner-centred approach to ensure quality learning. In order to support and foster the objective of the LS adaptation, the frequency of the LS cycle in Zambia is more than that of the JLS cycle. According to

Baba and Nakai (2011), teachers in Zambia group themselves according to their respective grades and the subjects that they teach and conduct LS every month with the duration of the cycle lasting for a week. On the contrary, Fujii (2014) attests that for the JLS cycle, the duration is sometimes more than six months.

In Zambia, teachers start the LS cycle by defining a problem or challenge which according to Likando (2018) entails teachers discussing problems, concerns, and challenges that they face in their practice for example, challenging topics, questioning techniques, and pedagogical approaches. Their lesson planning is not informed by a rigorous *kyozai-kenyu* as in the JLS cycle however, they do use the available resources for lesson planning. Furthermore, in Zambia, teachers set goals for the lessons aligning them to those of the MOE and not of the school as it is with the JLS. In addition, for the second step of the cycle – *collaboratively plan the lesson*, the teacher that will enact the lesson (known as the *demo-teacher*) individually plans the lesson before the "planning team" meets (Likando, 2018) which is not the case with the JLS cycle. According to Likando (2018), the planning team then critiques the lesson plan, and the demo-teacher modifies and finalises the script (the lesson plan). In the same meeting, the planning team defines the object of focus as observers during lesson presentation and allocate observation tasks to each teacher in the group for example, lesson introduction, use of teaching materials, lesson objectives (Likando, 2018). Furthermore, in Zambia, the *knowledgeable Other* (KO) or *koshi* is not invited throughout the cycle but rather the facilitator of the cycle ensures that all activities are done as expected.

Of difference to the JLS cycle during lesson presentation and lesson observation is that teachers in Zambia observe a lesson focussing on the assigned observation task and not on the whole lesson (Likando, 2018). Lesson enactment in Zambia is done using four teaching approaches that could be used simultaneously in a lesson namely, *Mastery Learning Approach*; *Inquiry-Discovery Approach*; "Activity, Student-Centred Experiment and Improvisation" *(ASEI)* / "Plan Do See and Improve" *(PDSI) Approach* and *Problem-Solving Approach* aiming to incorporate learners' different learning styles in a learner-centred teaching environment (Likando, 2018) whereas, with the JLS, the only teaching approach used is teaching through structured problem-solving (Takahashi, Lewis & Perry, 2013). In addition, during the reflection stage, there is no input of the KO since he/she was never invited from the planning stage. Likando (2018) contends that, after the revision of the lesson during lesson reflection, it is then taught again at the same level in

terms of grades but different audience. However, should it happen that there is only one class group of the grade, the class is split into half so that one half constitutes the audience for the demo-lesson and the other half for the revised lesson (Likando, 2018). Upon reflection of the revised lesson, Likando (2018) attests that the focus is on whether the lesson has been improved (whether objectives have been achieved) informed by the overt or covert behaviour of learners since lesson objectives are written in a behavioural way and the learnings that the teachers have gained. After which, the discussions are documented and then filed as school CPD report.

Baba and Nakai (2011) posit that during the half yearly holidays, teachers get together to reflect on the six lessons that were taught in the previous semester and plan lessons for the following semester. Also, the relevant school management personnel, prepare and submit a report for the term (six months) on school-based LS to the district office, the District Education Support Team (DEST) summarises the contents of the reports and share with other schools during workshops while noting outstanding practices to share at level platforms (Likando, 2018).

2.4.7 Lesson Study in South Africa (SA)

Ono and Ferreira (2010) attest that LS was implemented in SA because of a request that was tendered by former and late SA President, Nelson Mandela to improve teacher professional development. This request was stemming from the inadequate and non-impactful teacher training sessions that had been held in the previous political dispensation especially concerning mathematics and science teachers (Ono & Ferreira, 2010). According to Ono and Ferreira (2010), the cascade model of teacher professional development in SA had been proven to be ineffective as some important information seemed to be lost or misinterpreted in the process. In response to the request, JICA conducted studies to formulate the project and consequently came up with the inception of Mpumalanga Secondary School Initiative (MSSI) in 1999. On this initiative, JICA; Mpumalanga Department of Education (MDoE) and the University of Pretoria (UP) formed equal partnership and LS is the context at which it was done (Ono & Ferreira, 2010).

Therefore, as a result, the South African adaptation and contextualisation of LS is informed by five stages (Sekao & Engelbrecht, 2021). See Figure 1:

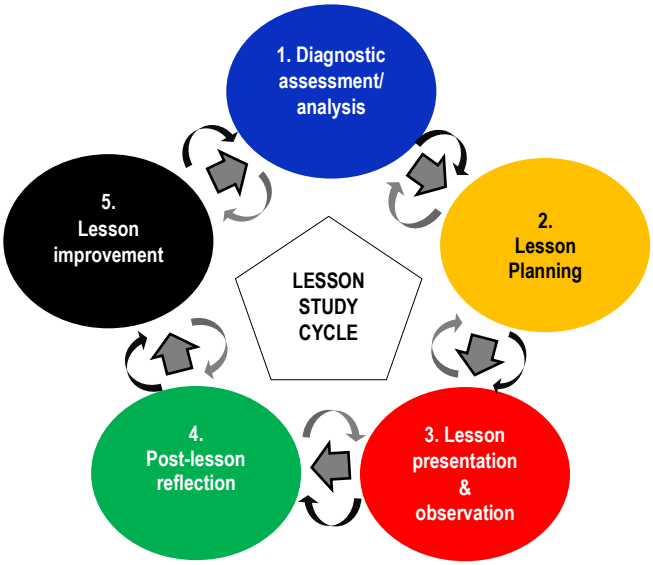


Figure 1: Lesson Study cycle in South Africa (source: Sekao & Engelbrecht, 2021)

According to Sekao and Engelbrecht (2021), the first stage of the SA lesson study (SALS) cycle is unique because the JLS cycle and many other countries do not have it. At this stage, the theme for the LS is developed. The focus at this stage is gathering data on what (concepts) will inform the LS discussion (Sekao & Engelbrecht, 2021). In SA, data is gathered using any of the two "tools" in no particular order firstly, through learner assessment and secondly, through teacher discussion on challenging topics for teachers to teach evident in poor learner performance in those topics (Sekao & Engelbrecht, 2021). Regarding assessment, Sekao and Engelbrecht (2021) contend that tests are conducted (whether school-based; cluster-based; district-based or provincial-based) or examinations. Learners' responses are then qualitatively analysed item by item using error analysis while identifying those items that seemed to be a challenge to learners, and items that flagged some misconceptions. These findings are then used to collaboratively plan a lesson. Venkat and Spaull (2015) argue that "teachers cannot help learners with content that they do not understand themselves" and that, the level at which PCK is relayed is directly determined by the level of content knowledge (SMK) that the teacher possesses. Therefore, as "the other" "tool" for data collection on what constitutes the theme (topic), teachers sit together and discuss matters on SMK and/or PCK (through experience – may it be stemming from the teachers themselves or maybe the learners) that hinder their effectiveness in their teaching practise (Sekao & Engelbrecht, 2021). Of importance to the SALS cycle during the planning stage is the crafting of lesson objectives which are pitched at the same level as the Curriculum Assessment Policy Statement

(CAPS) stipulates followed by the selection of “purposeful activities” that are going to assist achieve the lesson objectives.

Additionally, according to Sekao and Engelbrecht (2021), a subject advisor may be invited at the third stage to observe the lesson and participate in the post-lesson reflection however, unlike the in the JLS cycle, the KO may be part of the planning team and has a role to play during post-lesson reflection, there are no specified roles in the SA context that the subject advisor who is the KO assumes as the cycle continues.

Again, during post-lesson reflection, Sekao and Engelbrecht (2021) attest that in the SA context, it is very important to stipulate whether the lesson objectives were achieved or partly achieved and measures to improve the lesson if objectives were partly achieved should be in place.

The last stage, Sekao and Engelbrecht (2021) posit that the *lesson improvement* stage incorporates all the suggestions to improve the lesson that were discussed and finalised in the previous stage for documentation and sharing. With the JLS, this activity is done within their fourth stage – *reflect.* Of significant difference once again between the SALS cycle and the JLS cycle is the way the LS cycle occurs. In SA, the LS cycle is a cyclic and iterative process enabling teachers to move back and forth between two stages (Sekao, 2023) whereas in Japan, the LS cycle is cyclic and linear. In this study, there were instances where teachers felt that the lesson had to be modified before it is reflected upon. However, lesson reflection was not the focus of the study. Important to note is, although LS is implemented in SA, it is not yet widely institutionalized. There are also other forms of teacher professional development programmes besides LS. Predominantly, LS is used in in-service teacher professional development and teachers do LS as and when it is necessary, that is, when there is a need.

2.5 Location of my study within the SALS cycle

Although teachers completed the entire LS cycle, my study was confined to only two stages of the SALS cycle, that is, the second stage (*collaborative lesson planning)* and the third stage (*lesson presentation and observation)*. The selected topic for lesson enactment is *Numeric* and *Geometric patterns* in Grade 6. The selection of this topic was informed by both criteria mentioned under the discussion of step one (the diagnostic analysis) of the SALS cycle, that is, through learner assessment and teacher discussion

of topics that seem to pose a challenge for teachers to teach and consequently for learners to learn. Although there are other topics that learners seem not to understand well, or teachers find them difficult to teach, teachers chose patterns as the problematic topic for learners. Essentially, patterns (numeric and geometric) enhance learners' algebraic thinking which is a requisite skill for effective learning of algebra when it (algebra) becomes more formalised in higher grades in the schooling system.

2.6 (Mis) conceptions of globalisation of Lesson Study

As depicted in the previous section, the global implementation of LS had some challenges emanating from what Fujii (2013) referred to as the misconceptions of LS in the respective countries. However, the concern about some of Fujii's assertions was that different countries adopted and adapted LS depending on their respective contexts. The different contextual adaptation of LS, therefore, may not necessarily mean that it is a misconception. For instance, the perceived misconception regarding the teacher and not teaching as a focus reflection needs to be qualified because in instances where the teacher deviates from the collaboratively planned lesson, then he/she is likely to become the focus of reflection. In addition, Lesson Study can take a form of traditional workshop when it is introduced for the first time to teachers. However, some of the "misconceptions" expressed by Fujii (2013) are valid and include: think that the research lesson must be taught exactly as it is scripted, view structured problem solving as just solving a task, and think that the research lesson should always be retaught. Nevertheless, there are also instances where a proper conception of LS yielded good lessons and benefits that have been learnt and incurred by teachers, learners, and the respective education departments (Fujii, 2014). These lessons have assisted in fine-tuning the implementation. Therefore, I further discuss some documented benefits of not just LS but benefits of improving teachers' content and pedagogical knowledge as well as challenges that the implementation of LS has had in the respective countries.

2.7 Benefits of Lesson Study.

Gallagher and Bennett (2018) posit that the so-called traditional model of teacher professional development (PD) with no follow up tend to be ineffective in impacting teacher practice. A continuous support over a longer period of time tends to be a more sustainable way of teacher PD (Gallagher & Bennett, 2018). Teachers' understanding of

the content that they teach facilitates learners' learning as they (teachers) tend to ask thought-provoking questions which stimulate critical thinking and problem-solving skills as they enact the curriculum (Hattie, Fisher, Frey, Gopak, Delano Moore, Mellman, 2016). There are other models of teacher PD other than LS but whose features and goals is to improve teacher practice of which coaching is one of. According to Netolicky (2016), there are eight different types of coaching: cognitive coaching, peer coaching, expect coaching, technical coaching, literacy coaching, team coaching, collegial coaching, and instructional coaching. I argue that the aforementioned types of coaching are in one way or the other embedded in the LS processes. Marynowski, Darroch, Gregory, and James (2022) contend that the benefits of a sustainable coaching model is: being able to learn and collaborate from a consistent group of people, being held accountable for the task given to you by the group, aspect of practicality to the sessions facilitate better understanding, and sessions held over the course of a year to ensure professional growth.

A study conducted by Coe, Carl, and Frick (2010) in the rural primary schools reveals some benefits that were highlighted by teachers who were the participants of the study. Some of these benefits include teamwork stemming from collaborative practice, transforming new instructional approaches (Coe, Carl & Frick, 2010). Furthermore, Posthuma's (2012) study revealed that the quality of teacher planning lessons in the context of LS improved over time as teachers considered their learner needs and the teaching became more learner centred. In addition, teachers' level of confidence in teaching mathematics improved. Coe et al. (2010) attest that one other benefit of LS is that it serves as a vehicle that supports continuous professional teacher development (CPTD) program.

2.8 Challenges to the implementation of Lesson Study

The first step in the implementation of the JLS model whether adopted *in toto* or glocal, is to discuss the original JLS (Groves, Doig, Vale & Widjaja, 2016, Gutierez, 2015). In addition, Grimsæth and Hallas (2016) argue that in the process of "marketing" a new teaching model to authorities, teachers and other relevant stakeholders, focus tends to be more on the successes of countries that have effectively implemented the model or overemphasise on the negative impact of the current model on teaching and learning. It is very rare that complexities that could have been encountered before the

implementation and contextual factors that impacted on the success of the model, form part of the model's advocacy (Grimsæth & Hallas, 2016). Henceforth, are discussions on challenges that some of the countries experienced when implementing the JLS.

Lack of time allocated for implementing teacher professional development programmes normally limits or hinders the effectiveness of the implementation (Jamil, Razak, Raju, & Mohamed, 2011). Similarly, Marynowski et al.'s (2022) study on exploring a sustainable coaching model of teacher PD revealed that barriers to the implementation of a sustainable teacher PD model were time away from the classroom, unavailability of substitute teachers as participant teachers attend the PD sessions, no time to implement new learnt strategies in the current year and inadequate attendance due to the PD session being optional.

In the South African context, Coe et al.'s (2010) study revealed that the unavailability of collaboration time for lesson planning, and the unrealistic expectation that teachers instantly become good researchers posed a challenge. In line with the above assertion from my experience, the general challenges that emerge as a result of implementing any professional development model are minimised contact time as teachers have to move away from the school to meet with the group, lack of support from school management, and lack of time in terms of pacing to present the strengthened lesson as teachers in the IP are generalists and therefore do not teach only mathematics. Furthermore, Posthuma (2012) attests that some of the challenges that were experienced in the Western Cape province of South Africa were observed during lesson presentation/observation. Findings revealed that, teachers were not able to direct learners' incorrect responses to arrive at the correct ones, but rather, moved on. Could this in a way imply that teachers had limited content gaps as Hattie et al. (2016) contends that teachers with adequate content knowledge are able to ask deep questions that stimulate leaners to think critically and improve their problem-solving skills?

A South African study conducted by Ono and Ferreira (2010) aimed at improving mathematics and science learning through Lesson Study in secondary schools found that, the predominant challenge with lesson planning was curriculum pacing. Teachers were less concerned about learners understanding the concepts but more concerned about completing the curricula. This pacing challenge surely talks to the misconstrued attribute of LS. However, the project died on the way due to several reasons of which some were;

no time to meet since teaching time would be compromised during notional time and not enough manpower to monitor and support the implementation since this project was done in the whole province (Ono & Ferreira, 2010). When teachers were asked to identify one process of LS, they found useful to them, they favoured lesson planning because they felt that it broadened their scope pertaining to the development of mathematical skills (Ono & Ferreira, 2010). This then contributes to the notion that a teacher PD programme that is teacher driven and addresses the needs of the teachers, impact positively on the teachers' practice.

As mentioned in the previous paragraph, some Asian countries as well as Australia, implemented JLS *in toto* however, they did experience some challenges in its implementation. Using Australia as an example, Groves, Doig, Vale & Widjaja (2016) contend that some of the challenges experienced include: teachers' lack of skill of designing tasks that would match the Australian curriculum with the LS teaching model – teaching through problem solving approach as the local textbooks did not cater for this approach; Australian teaching culture of teaching small groups within the class as compared to whole class teaching also caused a challenge as teachers would tend to teach the groups during *kikan-shido* stage; learners were not used to discussing problems and teachers experienced challenges in engaging learners in robust discussions during the *neriage* stage.

In addition, Groves, Doig, Vale and Widjaja (2016) contend that teachers had a challenge anticipating learners' solutions or responses because of lack of experience of teaching through problem-solving (TTP) and ended up having trailing problems or the same problems to a different cohort of learners, but of the same grade to assist them complete their lesson plan in as far as learners' anticipated responses and thinking are concerned.

The Philippines is again one of the Asian countries that adopted the JLS in toto. Due to varying context and culture with respect to Japan, they too experienced some challenges in the implementation of LS. According to Gutierez (2015), one of the prescribed teaching approaches in the Philippines had been inquiry-based teaching but teachers had demonstrated lack of confidence in the approach. Some of the challenges revealed include: lack of confidence - teachers lacked confidence in using the LS model at its inception during initial training workshops (the training was more of a lecture and not intensive or hands-on); unavailability of inquiry-based teaching material (textbook(s);

content in the textbooks not aligned to the inquiry-based approach); teachers putting more emphasis on the assessment of content learning rather than learning through inquiry (this is also subject to amount of topics that teachers are expected to cover in the set time given); formulating and integrating thought provoking questions for learners' activity (teachers focus mostly on how to quickly finish the topic and less on learners' understanding due to the number of topics that need to be covered within a limited time); teachers giving learners too many uninformed activities (because of the belief that the more the activities, the better the learning); principals' lack of subject content knowledge although they supervise teachers (lack of interest on the principals because of inability to support, advise and develop the teacher's pedagogical knowledge); time consuming nature of the inquiry-based approach (most elementary school teachers teach all subjects in their classrooms *vis a vis* curriculum coverage).

Furthermore, Mon, Dali, and Sam (2019) conducted a study aimed at exploring factors that possibly supported or hindered the implementation of LS in the Malaysian education context. They found the hinderances to effective implementation of LS to be as follows: *time constraints* - LS sessions held rarely had the total expected number of participants due to other genuine work-related commitments that teachers were committed to and, if conducted after school, some teachers were reluctant to stay due to personal commitments after work; *teacher's workload*-"heavy" workload discouraged teachers from participating in the professional development programme because they had work to finish in a specified time; *teacher's perception of teaching observation* – some teachers were not at ease about being observed by peers as they thought they would be exposing their weaknesses and discrediting themselves to their peers; *lack of teaching knowledge and confidence* – teachers that needed to be professionally developed in their teaching knowledge were ironically the ones who tended to shy away from the LS session as they viewed LS as a threatening environment on their confidence; *teachers' teaching conception* – some teachers were sceptical in terms of whether or not the syllabus will be finished using the LS teaching model because they believed that at a secondary school, some concepts need to be told (teacher-centred approach) to learners and then tended to withdraw from the programme and finally, teachers' attitude towards professional development was greatly influenced by the above mentioned constraints impeding on effective implementation of LS. Furthermore, teachers' perception of LS specifically

lesson presentation was just a “show” and they perceived LS as more for collaborative lesson planning than it was for professional development.

In Norway, Grimsæth and Hallas (2016) used a four-stage composite-process model namely, cross-national attraction; decision-making; implementation; and internalisation as a framework to reflect on challenges that were encountered in localising the JLS model using four teacher groups from three schools. Obviously, less challenges (if any) would have been encountered in the first two stages because they involve ministry and are more theoretical than practical. Their aim was to develop attitudes, general knowledge, learning and most of all, skills of collaborative teaching. The existing cultural behaviour in terms of teaching and learning in Norway was that of teachers working in silos, no collegiality, no critiquing of one another’s work or even feedback and little focus on quality teaching (Grimsæth & Hallas, 2016). As a result, during the implementation stage, they found that teachers’ analysis of their own research lesson was negatively impacted by their lack of experience in collegiality, collaboration, co-planning, and inadequate skills for constructive criticism. Grimsæth and Hallas (2016) contend that the last stage of composite-process model, internalisation, is confirmed when the borrowed idea of the policy is relived through practice in the borrowing country. They argue that internalisation in terms of “absorbing the external features” (p. 118) was evident during implementation but in terms of “synthesis” (spreading LS in all schools throughout the country), they would need a lot more time and therefore could confirm that JLS was internalised in Norway.

Seleznyov (2019) conducted a case study aimed at examining the way in which the JLS was understood and implemented using one of the best secondary schools in London that had practiced LS for the past five years. Seleznyov (2019) reported findings of this case study guided by the “critical component of LS” highlighted in Seleznyov (2018) and articulated in section 3 above. She found that in terms of *identifying focus*, teachers seemed to be ignorant in identifying the theme for the school because even the themes that were suggested by other members of the groups were not incorporated in the lesson plan, they were simply ignored, in as much as they did have a *koshi* among them; for *planning*, very little *kyozai-kenyu* took place as a result of limited resources that teachers had to use, teachers coming to the lesson planning session not having pre-planned covering possible activities, potential challenges with them, possible solutions and anticipated learners’ response so as to minimise time spent and enable the session to be more productive, however, teachers agreed that initially they had been writing lengthy

lesson plans but because of work and time pressures in terms of curriculum coverage, they stopped doing it ; *research lesson* – observers actively participated in the lesson through engagement with learners and the presenting teacher and no evidence of learning on the learners' side was collected but rather teachers' questions and thoughts about learners' responses and the lesson itself; *post-lesson discussion* – there was no facilitator and no proper procedure was followed; *repeated cycle of research* – teachers were expected to have repeated the LS cycle at least three times in a year but due to limited time, none of the groups could manage the minimum expected number of cycles in a year; *outside expertise* – there was no koshi but a senior leader which poses a challenge regarding issues of respect during interviews; *mobilising knowledge* – no effective mobilisation of knowledge had been achieved.

Furthermore, Seleznyov (2019) attributes the above challenges to the following themes: some critical elements of the JLS have *diluted over time* due to teachers' lack of understanding of the vital elements of the model; *choice vs obligation* because teachers were given a choice in which the LS cycle would work, no accountability and no timeframes; teachers seeing no value in LS and therefore resistant to its implementation; LS being time consuming but all teachers understood and valued the purpose of LS very well.

Singapore is one of the Asian countries that implemented the JLS with no adaptations Lim, Lee, Saito and Haron (2011) present several factors that they found in their study to be important to sustain LS in Singapore, amongst many, was the suggestion that there should be protected time for LS meetings. They found that high school teachers' attendance in the LS meetings was better than that of primary school teachers due to primary teachers teaching all subjects and constrained in terms of time and high school teachers specialising.

2.9 Conclusion

Evidently, research indicates that while LS outside Japan exists in various adaptations, often its superficial understanding impacts negatively on its implementation outside Japan. The understanding of LS outside Japan is informed by an individual's understanding and interpretation more than it is informed by explicit definition (Winsløw, Bahn, Rasmussen, 2018). In addition, Winsløw et al. (2018) further argue that the vast difference in cultural milieu also contributes a great deal to poor implementation of LS

outside Japan. Fujii (2016) attests that while it is imperative for teachers to fully understand the most catching elements of the LS such as the research lesson and lesson reflection, it is also just as crucial to understand the elements “behind the scenes”, that is, designing a lesson and what it entails.

In many countries that are implementing LS outside Japan, their LS cycle involves re-teaching of the research lesson after it has been discussed and reflected upon. While Fujii (2014) regards this as a misconception because it [the research lesson] is not re-taught in Japan, Winsløw et al. (2018) argue that it is imperative for the iterative re-teaching of the research lesson in countries outside Japan because change in learners’ behaviour, understanding and learning of the concept as well as the teachers’ mathematical praxeology can be recorded as compared to just adapting the research lesson.

In terms of LS sustainability in countries outside Japan, Takahashi, and McDougal (2017) attest that institutional and financial support; clear communication during workshops on LS, LS allocated time; ongoing LS advocacy; and compelling school goals determine the success of LS. On the other hand, Lim, Teh, and Chiew (2018) suggest that for LS to be sustainable for non-Japanese countries, LS could be rolled off as a teachers’ professional learning culture; knowledge and skills (in lesson planning, observation and reflection) needed for effective LS need to be enhanced; expert teachers could be engaged to play the role of the KO and CLR and LS could be used interchangeably during teachers’ practice since they are constituted by the same elements. Therefore, I conclude that, during the process of LS implementation, a consideration and embedment of the above suggestions for effective professional development through LS, would ensure movement from implementing ineffective teacher PD models to implementing more sustainable models.

CHAPTER 3: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

3.1 Introduction

This chapter presents the theoretical framework that frames the study and the review of the literature pertinent to the study. This study is underpinned by two lenses that is, the Mathematics Knowledge for Teaching (MKT) framework advocated by (Ball, Thames & Phelps, 2008) and modes of teacher engagement with the curriculum materials espoused by Remillard (2005) and Brown (2011). Both these lenses are used as a blueprint to guide and anchor the literature review, conceptualisation of research questions, methodology and data analysis. In this chapter I started with a detailed exposition of MKT and Remillard (2005) and Brown's (2011) modes of teacher engagement with the textbook, then focused on the review of literature to gain and share insights into the research conducted in relation to the current study. Although Japanese Lesson Study was dealt with comprehensively in Chapter 2, I have briefly reflected on it in the context of teacher development in the current chapter.

3.2 Theoretical Framework

As mentioned above, this study is framed by two lenses namely, the MKT framework by Ball et al. (2008) and Remillard (2005)/Brown's (2011) modes of teacher engagement with curriculum materials. Even though both Remillard and Brown's concern is on teacher-text relationship with curriculum materials, this study focusses on only one form of curriculum material, the textbooks. Details of how two theoretical lenses frame my study are discussed in the next sections.

3.2.1 Mathematics Knowledge for Teaching

Shulman (1987) introduced the concept of pedagogical content knowledge (PCK) and defines it as knowledge that is 'amalgam' of knowing how learners engage with the subject as well as effective ways of representing the subject for learners to discern learning. According to Shulman (1987), there are seven categories of the knowledge base for teaching, namely, (1) content knowledge; (2) general pedagogical knowledge; (3) curriculum knowledge; (4) pedagogical content knowledge; (5) knowledge of learners and their characteristics; (6) knowledge of the context; and (7) knowledge of educational end, purposes, and values. While attesting to the fact that knowledge bases are not fixed or

rigid, Shulman (1987) presented a cyclic model of pedagogical reasoning and action (MPRA) that a teacher needs in teaching. The actions are **comprehension**, **transformation**, **representation**, **selection**, **adaptation**, **instruction**, **evaluation**, **reflection**, and **new comprehension**. These actions are embedded in the above mentioned seven categories of knowledge. Shulman defines these categories as follows: comprehension concerns itself with teachers' understanding of subject (content) knowledge and ideas to be taught, how ideas within and outside the subject are interrelated and connected and, the purpose and aim of teaching. Transformation refers to altering content knowledge to representations that enables teachers to teach catering for all learners' learning styles for the content to be understood by learners, deliver instruction through engaging with learners and organising and managing the classroom, assess learners' learning - informally and formally and teachers' performance – through the effective use of for example teaching aids. It is important to note that the following three actions namely, representation, selection and adaptation are embodied in the transformation action. Representation refers to the different way of presenting an idea. Shulman defines selection as the choice of instructional approach that teachers choose while adaptation refers to teachers' tailor-making activities for learners to understand. Instruction refers to the pedagogical, disciplinary, and contextual interactions that take place during lesson presentation between the teacher and the learners. Evaluation involves checking learners' understanding, at the end of the lesson, of the concepts taught during the lesson presentation. Reflection refers to the teacher looking back and critically analysing the performance of the teacher and that of the learners and act based of the findings, for example modify the lesson and re-enact or move on to new comprehension if findings depict that learning did take place. I conclude that Shulman's seven categories align themselves exactly with the component of MPRA meaning, content knowledge (first category) aligns with comprehension (first stage of MPRA) and the pattern follows in the same order respectively but, the last category (knowledge of educational end, purposes, and values) encompasses both evaluation and reflection of the MPRA.

However, the critical measure that distinguishes the knowledge base of teaching lies at the intersection between the teachers' knowledge of content and pedagogy, for the teacher to transform the content knowledge that he/she possesses to a powerful pedagogical knowledge catering for all learners' background and learning styles

(Shulman, 1987). To avoid confusing the word *task* due to a range of meaning it has in the field of mathematics education (Watson & Mason, 2007), I interpreted Shulman's assertion of the term *task* and used it in the current study to refer to the portion of mathematical work (activity) set for both learning and teaching. Doig (2013) attests that the notion of the task and the problem are linked and therefore can be used interchangeably. In the context of Lesson Study, the *task* or the *problem* is referred to as *hatsumon* in Japanese (Watson & Mason, 2007). In this study, the word task is defined by more than one activity. That is, two or more activities form a task. Further, Doig, Groves and Fujii (2011) argue that regardless of how a task is defined, the function is to stimulate the mind of learners, of which I agree.

According to Ball et al. (2008), there were gaps in Shulman's (1987) concept of PCK. They argue that *firstly*, in as much as Shulman's concept of PCK was considered an essential knowledge base that teachers need to have, studies on how it relates to learners' mathematical thinking and ideas, knowledge of the content and student, was quite thin; and *secondly* there had not been sufficient measures to determine teachers' PCK since there seemed to be a weak amalgam between PCK and subject matter knowledge (SMK). Ball et al. (2008) posits that Shulman's work was more generic and not specific to a specific content. According to Ball et al., Shulman focussed more on teacher proficiency and teaching behaviours and less specific on subject content. Consequently, they refined Shulmans' categories by being more content specific. Mathematics Knowledge for Teaching (MKT) framework, therefore, resulted from Shulman's model and it aimed to address the aforementioned gaps emanating from Shulmans' work.

Ball et al. (2008) refers to the repertoire or bank of knowledge that mathematics teachers need to have to effect teaching and learning as the *Mathematics Knowledge for Teaching* (MKT). They refined Shulman's categories into two main domains, namely, subject matter knowledge (SMK) and pedagogical content knowledge (PCK) and subdivided each domain into three sub-domains as illustrated in Figure 2

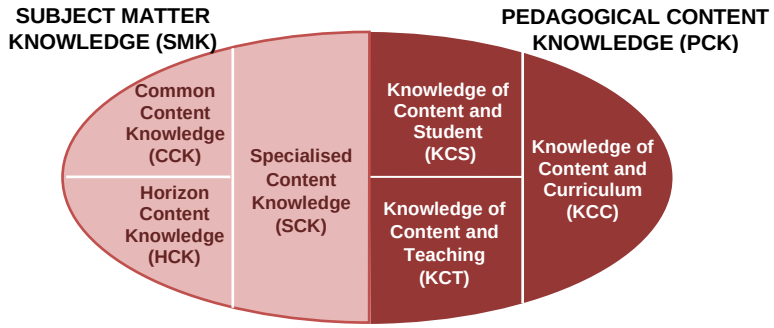


Figure 2: Framework of Mathematics Knowledge for Teaching (source: Ball et al., 2008)

According to Ball et al, (2008), the first domain is the SMK characterised by the three sub-domains referred to as, **Common Content Knowledge** (CCK), **Specialised Content Knowledge** (SCK) and **Horizon Content Knowledge** (HCK). Ball et al., (2008) attest that CCK concerns itself with mathematical knowledge and skills (basic algorithms) that are not only understood by mathematics teachers but are also commonly understood by everyone and are used in different settings outside the teaching profession.

Specialised Content Knowledge (SCK) encompass mathematical knowledge that only mathematics teachers possess, for example, teachers need to know the subject content. SCK is the knowledge required for mathematics teachers to be able to "trace the thinking" (Ball et al., 2008, p. 4) involved in solving the problem, explain what I would call the *hidden algorithm* in problems and critically evaluate the correctness of algorithms in problem(s). For example, in the context of *numeric and geometric patterns*, people who are not mathematics teachers can use their CCK to make beads as a clothing accessory or use beads as a material to decorate ornaments but, the arrangement and extension of beads in terms of how a pattern is formed mathematically may only be explained by the mathematics teacher using his/her SCK). Ball et al. further asserts that when teachers select tasks during lesson planning, they need to think about the following: (1) how learners are likely to think about the same tasks once presented to them during enactment; (2) tasks that learners will find interesting and motivating; and (3) critically listen to learners' response so that they can probe them to arrive at the desired outcome. Moreover, for teachers to be proficient at SCK, Ball et al. (2008) attest that they also need to think of the context that works best for learners. Teachers can do this by considering the aspects of context that would support or impede learners' understanding, aspects that makes learning attainable or unattainable (Ball et al., 2008). Informed by Ball et al.'s assertions above, it is evident that CCK is more tacit or implicit while SCK is more explicit.

Regarding Horizon Content Knowledge (HCK), Ball et al. contend that it refers to teachers' awareness of the integration of topics within the curriculum. For example, at the Intermediate Phase (Grades 4 to 6) level, teachers need to understand that as rules are generated to be able to extend a numeric or geometric pattern, they result in the formation of algebraic expression leading on to number sentences. As learners progress to the Senior Phase (Grades 7 to 9), the same number sentences are now referred to as algebraic equations. HCK is neither specialised nor common, instead involves teachers' awareness of the larger scope of mathematics discipline beyond the conceptual demands of the current grade level (Ball et al., 2008).

The three sub-domains of the second domain, i.e., PCK, include **Knowledge of Content and Student** (KCS), **Knowledge of Content and Teaching** (KCT) and **Knowledge of Content and Curriculum** (KCC). KCS refers to the combination of knowledge about the content and knowledge about the student. KCS is the knowledge that teachers need to have to depict the best instructional approach that can be used to discern a fruitful lesson during lesson planning using a hypothetical *learning trajectory* (Ball et al., 2008). According to Ulfa and Wijaya (2019), a hypothetical *learning trajectory* involves (1) topic to be taught and methodology, (2) objectives to be achieved by the learners by the end of the lesson and, (3) selection of tasks that are going to ensure that the objectives are achieved by the learners.

Knowledge of the Content and Teaching (KCT) refers to the combination of knowledge about the content and didactics of teaching mathematics (Ball et al., 2008). KCT concerns itself with teachers having to select and sequence tasks that are going to foster learners' understanding of the topic, evaluating the advantages and disadvantages of the instructional methods, and choosing the one that will best assist in meeting the lesson's objectives, understanding the level of difficulty the selected task has and deciding on the prior knowledge that learners need to have to improve their understanding of the current task. In addition, KCT involves characteristics such as teachers noticing inaccurate answers from the textbook, knowing when learners sponsor incorrect answers, using correct vocabulary and notations when writing on the board, able to work out answers to the task and activities that they expect learners to do, have the knowledge of how to "dissect" the task to its constituent features to foster learners *mathematisation* skills and fluency (Ball et al., 2008). Therefore, proficient teachers in the KCT need to demonstrate

meaningful coordination between the presented task and instructional options (Ball et al., 2008).

Knowledge of the Content and the Curriculum (KCC) refers to knowledge of the curriculum (Ball et al., 2008). KCC entails teachers' knowledge of how topics (concepts) are interrelated within the mathematics discipline beyond the current grade level and how topics can be integrated to other disciplines outside the mathematics discipline.

Henceforth, Ball et al. (2008) raised a concern of whether HCK should be a stand-alone sub-dimension or be embedded or intertwined in all the sub-dimensions of MKT? In as much as Ball et al.'s concern is not the focus of this study I would like to concur to the Ball et al.'s notion of HCK being embedded in all other sub-domains informed by the following reason. Evidently, Wasserman and Stockton's "planned work of teaching" is about KCT and "in-action work of teaching" overlaps with KCS. Also, Shulman's definition of vertical curriculum overlaps with Wasserman and Stockton's curricular mathematical horizon because the focus is on the teachers' knowledge of what content was taught in the previous grades and what is to be taught in the next grades. Wasserman and Stockton's advance curricular horizon overlaps with SCK and CCK because it focusses on the teachers knowing more than the learner. This then highlights the embeddedness of HCK sub-domain in all the other sub-domains.

In this study I explored teacher engagement with textbooks in the context of Lesson Study (LS). Using the MKT framework, I focused on encapsulating elements of the participants' conversation which encompassed features of SMK and PCK. Over the years to date, studies have proven that one of the main curriculum resources used by teachers to teach mathematics at schools are textbooks. Textbooks are written informed and guided by the policy (CAPS). CAPS also informs the sequencing and pacing of content covered in the annual teaching plans (ATP), which are work schedules meant to package the contents of the policy into manageable chunks for easy implementation at school level.

For teachers to be able to engage with the textbook, they need to have some knowledge base of both the content and the pedagogy. That is, a blank person in terms of the content knowledge and pedagogical content knowledge of a respective grade and discipline would not be able to engage meaningfully with the textbook. Additionally, through teacher-text engagement, SMK and PCK are enhanced. At this point, it is imperative for me to highlight that this study did not in any way intend to quantitatively measure teachers' SMK

or PCK. Instead, the knowledge strands contained in the MKT framework and the two selected Lesson Study stages, namely, collaborative lesson planning and lesson presentation, enabled me to qualitatively respond to the research questions. Remillard (2005) and Brown's (2011) mode of teacher engagement with the textbook are not included in the table because, (1) the mode of textbook engagement teachers adopted was informed by research question 2, research question 3 and, research question 4 over three lessons, and (2) teacher-text engagement was implicit as teachers collaboratively planned and presented lessons. However, it is also important to note that research questions may be qualified by more than one domain and sub-domain as shown on in Annexure A. Annexure A juxtaposes the research questions with the MKT framework. Noticeably, research question 1 and research question 3 cover only one domain of the MKT framework each namely, the SMK and the PCK, respectively. Furthermore, if mathematics teachers engage with textbooks such that their engagement contributes to teachers' improved understanding of *patterns*, their SMK could in turn be improved.

3.2.2 Modes of teacher engagement with textbooks

Remillard (2005) and Brown's (2011) modes of teacher engagement with the textbook assisted me to understand the conceptualisation of the central construct of this study: How do Grade 6 mathematics teachers engage with textbooks during the Lesson Study session? Therefore, I was able to respond to the broad research question using Remillard and Brown's mode of teacher-text engagement.

Remillard (2005) suggests four conceptualisations of curriculum use, which, by implication explains how teachers engage with textbooks: *following*, *subverting*, *interpreting,* and *participating with.* Engaging with and using textbooks by *Following* is when teachers use them with fidelity. In other words, textbook activities are used during lesson presentation as they were, without being altered, from the textbook. When teachers *subvert*, they alter or transform the textbook selected activities to suit their teaching approach (Remillard, 2005). *Interpreting* mode concerns itself with the kind of interpretations teachers make as they engage with the textbook, the influence that these interpretations have on classroom practice. *Participating with* is the extent to which the knowledge and information presented in the textbook matches with the teacher's interpretation of that particular concept (Remillard, 2005). On the other hand, Brown (2011) presents three modes of teacher-text relationship which are in a way, in terms of

their descriptors, similar to the ones suggested by Remillard (2005). Brown's (2011) modes of teacher-text relationship are: *offloading*, *adapting*, and *improvising*. *Offloading* refers to transmitting knowledge from the textbook to learners with fidelity. While *adapting* refers to teachers altering text in the textbook to suit both the teaching environment and the audience, *improvising* refers to teachers' ability to design their own activities.

I used the MKT framework to respond to the four secondary research questions (listed in Annexure A) which in turn assisted me respond to the primary research question: *How do Grade 6 mathematics teachers engage with textbooks during the Lesson Study session* using Remillard (2005) and Brown's (2011) modes of teacher engagement with the textbook.

3.3 Literature review

In this section, I review studies on the relationship between the intended curriculum, the textbooks, and the implemented curriculum with respect to mathematics teaching and learning. It is important to note that although we are in the era of e-textbooks, this study focusses only on traditional textbooks. I further discuss the quality of tasks found in the textbooks that are primarily used by the teachers and the impact this has on teaching and learning. Furthermore, I discuss the educative features of the textbook followed by the relationship teachers have with the textbook in terms of how they [teachers] use it in general, during lesson planning and lesson presentation. Finally, I discuss issues of effective teacher professional development.

3.3.1 Curriculum materials, such as textbooks, as a conduit for teaching and learning

Policy documents (CAPS) specifies the content that is to be taught per grade, per term and the duration. Textbooks use the content stipulated in the CAPS to formulate activities that are going to assist teachers in the classroom meet the standards of the set policy. The teachers then use the textbook(s) that are CAPS aligned after the screening processes have taken place and approvals granted, to enact the curriculum in the classroom. Therefore, it is evident that the textbook serves as a conveyer belt that accepts content specified in the policy, processes it through interpretation and activity formulation, allows the content to be grinded through screening and then distributed for teachers to use in their daily teaching practice.

Herbel – Eisenmann (2007) and Remillard (2005) define a textbook as an artefact that serves as a conveyor of the curriculum - it mediates the intended curriculum and the implemented curriculum. According to Kajander and Lovric (2009), a textbook is a fundamental resource that shapes the way teachers teach mathematics. The National Council of Teachers of Mathematics (NCTM) had set standards in 1991 for authors to focus on the learners' reasoning and thinking ability more than just on the teacher and the textbook when developing textbooks (NCTM, 1991). Consequently, Herbel-Eisenmann (2007) examined the "voice" of a mathematics textbook from intended curriculum to written curriculum. The findings revealed that the task of developing textbooks to be more learner centred and have activities at a higher cognitive level was not found easy for the authors and as a result, there was a mismatch in the way the content was presented from the intended curriculum to the written curriculum, the set standards were not met.

Although this study focuses on the mathematics curriculum, researchers such as Polikoff (2015) have shown that the misalignment between the intended and the implemented curriculum is noted only to the mathematics curriculum. However, as Phaeton and Stears (2016) revealed, the misalignment is also prevalent in other subjects such as Biology. Phaeton and Stears investigated the alignment between the intended and the implemented curriculum using teachers' interpretation of the curriculum in the Zimbabwean A-level Biology curriculum. They found that there was a mismatch between the intended and the implemented curriculum emanating from the teachers' lack of knowledge of science process skills. Teachers were not keen to engage with the curriculum to understand its objectives but rather, interpreted the curriculum through examinations, that is, focussing on the assessed content (Phaeton & Stears, 2016). Therefore, Phaeton and Stears (2016) then argue that non-inclusion of subject teachers in curriculum design results in the misrepresentation of the intended curriculum in the classroom.

Sunday (2014) contends that in Nigeria, two mathematics teachers (direct users of textbooks) from all districts within the phase were selected at random for screening of mathematics textbooks of the grades they teach using the instrument that was subject specific. The findings revealed that the textbooks contained the expected feature of about 74,2% and did not meet all the policy set standards. These findings would be more reliable when the none – users (specialist) obtain the same result (Sunday, 2014). A

recommendation to the government to set up a standard or a pattern that can be followed by every author or publisher so that the layout of the textbooks is similar was made (Sunday, 2014). In the South African context, teachers are not part of the textbook screening process to ensure curriculum alignment; and the screening tool used is generic and not subject specific. Furthermore, textbooks are screened at one level only - by a subject specialist. Therefore, I argue that there must be a subtle gap in terms of the level of alignment of the SA mathematics textbooks to policy standards that could be narrowed if the screening tool was subject specific.

Remillard (2000) studied two 4th-Grade teachers by investigating whether curriculum support materials support teachers' learning. Findings revealed that a textbook that was mostly appealing to the teachers was the one that provided non-routine problems to solve and emphasised problem solving as a teaching/learning technique. Remillard (2000) also found that teachers learned more because they had to read beyond the textbook to enact the curriculum in a classroom discourse. Although teachers were able to appropriate tasks and learn through inventing tasks, they found that teacher guides assisted them because they contained not only the activities, but also descriptions of activities and suggestions on how to teach the concept (Remillard, 2000). In this context, Remillard argues that a teacher is seen as an active designer of knowledge and not only the transmitter or implementer of knowledge. However, Ball et al. (2008) challenges Remillard's findings by arguing that teachers can only be designers of knowledge if they are fluent in the mathematics content, that is, their CCK and SCK is fluent as advocated by Ball et al. (2008) in MKT.

The extent to which teacher engagement with textbook elicits their awareness of coherence between the intended (CAPS) and implemented curriculum (textbooks) is one aspect that this study seeks to explore. Valverde, Bianchi, Wolfe, Schmidt and Houang (2002) contend that the tripartite curriculum model consists of the **intended curriculum** (overt curriculum by the state reflected in national policies and official documents reflecting educational planning and objectives that must be followed by all educational institutions), the **implemented curriculum** (teacher's intentions and objectives in relation to the selection of activities and classroom instruction) and the **attained curriculum** (measure of what learners have learnt). Furthermore, Valverde et al. (2002) attest that in the tripartite curriculum model, textbooks form part of the *potentially implemented*

curriculum that links the envisaged goals to practical reality. Textbooks are regarded as the *potentially implemented curriculum* because they have the potential to assist teachers implement the intended curriculum goals and standards. Figure 3 illustrates the tripartite model:

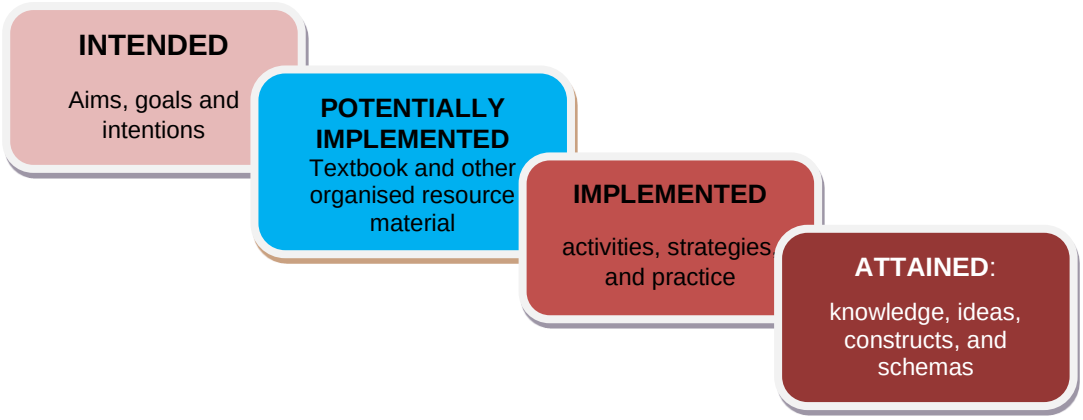


Figure 3: Textbooks and the tripartite model (Source: Valverde et al., 2002, p. 13)

Umugiraneza, Bansilal and North (2018) examined SA teachers' reports about how they integrate curriculum in their teaching of mathematics and statistics using 75 teachers offering mathematics from Grade 4 – 12. Findings revealed the following: Firstly, that teachers had minimal ideas on how to integrate the NCS in their teaching however, the primary school teachers had better ideas than the secondary school teachers. Secondly, younger teachers (≤ 40 years) tended to consult the curriculum document more often than older teachers. Thirdly, teachers who had attended subject content workshops interacted better with the curriculum than those that had not (Umugiraneza, et al., 2018). Furthermore, Umugiraneza, et al. (2018) attest that teachers could not make connections between the intended curriculum and the curriculum support material (textbook) however, some teachers identified vertical and horizontal links within and across the curriculum (due to their attendance of the PD workshops on content) but most of them were unable to establish ways of working within and across the curriculum for meaningful learning. Umugiraneza, et al. (2018) conclude by suggesting that PD programs need to prioritise ways in which teachers are made to navigate and work with the curriculum in a vertical and horizontal manner.

The way teachers view a textbook has a great influence on the frequency of its use. Van Steenbrugge et al. (2013) conducted a study on the teachers' view of the textbook and found that the series of the textbook predominantly used at a school matter significantly

because textbooks with no detailed description of the content, didactical suggestions, theoretical and mathematical background knowledge become less favourable to teachers. But, as it is the case in the South African context - there is no framework that guides or directs the writing of a mathematics textbook other than the CAPS itself, therefore textbook developers and publishers are inundated and subjected to their own interpretation of the presentation of the content. This then translates to teachers benefitting differently from their engagement with textbooks depending on the textbooks that they choose to use in as much as South African primary school mathematics teachers are encouraged to use more than one textbook as a resource. But the question is, do teachers know what features to look for in a mathematics textbook for maximum benefit? This could also imply that it is imperative for us (subject advisors) to educate our teachers on educative features to look for when ordering textbooks. Bearing in mind that teachers in the Intermediate Phase do class teaching – they do not specialise, curriculum implementation would subsequently be compromised in terms of quality if teachers end up using textbooks with less or no educative features.

Similarly, Davis et al. (2017) examined Middle School Mathematics Teachers' (MSMTs) perceptions of Common Core State Standard for Mathematics (CCSSM) and its impact on curriculum implementation. Data collected revealed eight factors that are impactful for effective implementation of the curriculum *inter alia*, **professional support**, **curricular resources**, **teachers' planning practice**, teachers' use of district-adopted and non-district-adopted curricular resources, influence of CCSSM assessment, teacher evaluation on classroom practice and environment, influence of CCSSM on classroom instruction and perceived rigor of the CCSSM (Davis et al., 2017). Of interest to this study, I will elaborate on three factors namely, professional support, curricular resources, and teachers' planning practice. Regarding professional support, teachers revealed that they had not received adequate support in terms of PD around the CCSSM and this was evident when teachers demonstrated that they were more familiar with the vertical curriculum of the grade they currently taught and less familiar with the vertical curriculum for other grades (Davis et al., 2017). In addition, Davis et al. (2017) attest that getting teachers to plan collaboratively as a PLC, or a cluster contributes a great deal into respective teachers' understanding of the vertical curriculum (embedded in Ball et al., KCC) in the respective grades and so familiarises them with the CCSSM.

Regarding curricular resources, teachers reported that there was a mismatch between the CCSSM and the curriculum resources. Teachers reported that the curriculum materials disabled them from assisting learners whose learning was impaired to learn the content and practices implied in the CCSSM for it [CCSSM] seemed not to cater for them. Finally, regarding teachers' planning practice, teachers reported that the CCSSM expected them to teach both for conceptual understanding as well as for procedural fluency while enabling learners to explore and engage in "productive struggle" when solving problems (Davis et al., 2017). As a result, Davis et al. (2017) contend that classroom instruction varied in terms of communication and exploration as well as change in the way MSMTs used the curriculum materials. They conclude that CCSSM seemed to be influential to the MSMTs classroom instruction in a more reformed way.

3.3.2 Type of tasks mediated by the textbook

Textbook content has an influence on mathematics learning (Mellor et al., 2018) since it serves as an *Intermediate variable* between the intended curriculum and the implemented curriculum (Fan, 2013). Mathematical tasks and activities enacted during instructional time are in many instances generally selected from tasks and activities found in the textbook (Lepik et al., 2015). Although this study does not focus on the quality of tasks in the textbook, quality of tasks directly impacts teacher selection of tasks from the textbook and in turn impacts on the quality of teaching and learning.

Vincent and Stacey (2008) conducted a study to elicit whether mathematics textbooks cultivated shallow teaching using the 1999 TIMSS video study and three topics in the Grade 9 Australian mathematics textbook of the three states focussing on: procedural complexity; type of solving process (using procedures, stating concepts, and making connections); degree of repetition; proportion of application problems and proportion of problems requiring deductive reasoning. They found that too many books had problems that were repeated and were of low procedural complexity; there was a considerable difference between the textbooks themselves as well as the contained topics within the textbooks however, the nature of the problems in the textbooks was like those in the video study. They concluded that textbooks may indeed result in what they termed as "shallow teaching syndrome" should they be characterised by low procedural complexity with significant repetition and absence of deductive reasoning. Could it be that South African poor learner performance in TIMSS over the past years is as a result of the way textbooks

are conceptualised and written? As mentioned before in Chapter 1, in South Africa, there is no framework guiding the publishers or the authors, no subject-specific tool for textbook screening and, where the choice of activities depends on the author(s) interpretation of the curriculum, it is likely that some textbooks would be subjected to *shallow teaching syndrome*. That means, they will tend to be less educative and in the context of this study, would not contribute much to the teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK).

Textbooks that are rich in content knowledge and pedagogy will assist teachers enact quality tasks in the classroom (Krajcik & Delen, 2017). Gracin (2018) concurs with Herbel-Eisenmann by asserting that while textbooks in Denmark are an important resource for teaching and learning, tasks within the textbook seem not to balance in terms of cognitive levels. More tasks seem to be located under lower cognitive levels for example computation and underrepresentation of higher order questions that require learners to interpret, reflect and give open responses to questions (Gracin, 2018). In addition, according to Pratama and Retnawati (2018) higher order thinking skills (HOTS) are one of the skills needed for the 21st century and, teachers and learners HOTS could be developed through mathematics textbook as one of the resources. They substantiate their assertion by arguing that teachers' teaching strategy and the selection of teaching materials is directly influenced by the textbook teachers use (Pratama, & Retnawati, 2018). The greater the density of HOTS in the textbook, the greater the chance of HOTS taught to learners (Pratama, & Retnawati, 2018). Borko et al. (2015) contends that learners' poor performance in mathematical problem solving does not only emanate from the lack of mathematical knowledge but also from their unawareness of how to activate their knowledge. This means, while a textbook may have a lot of activities in terms of quantity, quality of tasks with varying cognitive demand is of utmost importance. The question then is: do South African textbook assist teachers teach HOTS or not?

Mellor et al. (2018) compared the presentation of *linear functions* in two Grade 9 textbooks, one from South Africa (*Classroom Mathematics - CM*) and one from German (*Elemente der Mathematik - EDM)*, and their affordances to learning at a school that offered mathematics in both languages. The findings showed that at Grade 10 level, learners who pursue the academic stream of obtaining a National Senior Certificate (NSC) and therefore choose to do mathematics, upon merging the English and the

German class from Grade 9, had been exposed to different affordances to learning *linear functions* (Mellor et al., 2018). This finding emanated from a number of factors such as, *presentation of content:* EDM presented the content for conceptual understanding while CM concentrated of procedures, CM provided guiding questions while EDM provided tasks that were more cognitively demanding, CM began with the concept first before the iterative arrangement of content while EDM consistently used the iterative approach, CM included a lot of tasks dealing with one type of representation while EDM linked representations, for example, linear equations to graphical representation and lastly, EDM created links between linear functions and other topics within the subject content and the real world (Mellor et al., 2018). Mellor et al. (2018) conclude by asserting that it is therefore very important for Grade 10 teachers to be aware of the affordances to learning that learners may have been exposed to and consequently "tailor make" lesson plans using both textbooks (where necessary) to bring learners to the same level of understanding of the concept and afford them the same learning platform. This is what Ball et al., (2008) refer to as HCK. Secondly, mathematics teachers in the IP do not specialise in a specific subject, and therefore they may not individually have the expertise to formulate tasks that are cognitively demanding if mathematics is not one of their strong subjects, and solely rely on textbooks.

According to Lester (2007), setting low cognitively demanding tasks would result in "teaching for skill efficiency" (accuracy) and setting high cognitively demanding tasks would result in "teaching for conceptual understanding" (mental connections among concepts). Different kind of teaching will yield different kinds of learning and that "teaching for conceptual understanding" is of great interest in mathematics education (Lester, 2007). According to Boaler and Stapes (2008), student learning using high cognitively demanding tasks is due to teachers' ability to maintain the level of demand during lesson presentation through questioning. They conclude that teachers need to be professionally developed so that they can build capacity to enact high level tasks. From this, it is evident that the *process-product* paradigm by Lester (2007), where the process is what learners are taught and the product is what they learn, presents learners' opportunity to learn in different ways. This study uses the context of Lesson Study to ensure that teaching is for conceptual understanding.

Sugiyama (2008) distinguishes three levels of teaching which were later summarised by Takahashi (2011), *inter alia*, level 1: the teacher provides the "what" and "how" aspects

of the content to the student and the approach is teacher-centred; level 2: the teacher provides the "what", "how" and "why" aspects of content to students as he/she explains the meanings and reasons behind the basic mathematical ideas to enhance their understanding and the approach is still teacher-centred and level 3: the teacher provides learners with an opportunity to explore the mathematical ideas while directing and supporting their learning. According to Sugiyama (2008), teachers must be able to select good tasks from the textbook, consider students' prior knowledge and more crucially, "nurture students to apply their knowledge to new situation". In addition, Doig, Groves and Fujii (2011) claim that level 3 teaching solely depends on a profound and powerful *kyozai-kenkyu* by the teachers during lesson planning.

For the goals of the core curriculum standards pertaining to the envisaged learner to be achieved, strategies focussing on narrowing gaps in the interpretation of the curriculum, writing and screening processes of textbooks must be implemented. This will aid the alignment between the intended curriculum to the potential curriculum. Again, thorough training on the curriculum standards to ensure that teachers understand what is expected of them, monitoring of the curriculum implementation, support, and evaluation of progress in terms of curriculum implementation is of utmost importance to avoid teachers being selective in terms of content. This could enable teachers to build a closer relationship with the curriculum policy (CAPS) itself while using textbooks. Lastly, there seems to be a gap or a shortfall in the weighting of the cognitive levels in the South African curriculum compared to the learners' cognitive demand in the international studies which may be narrowed by adapting the curriculum and the textbooks.

3.3.3 Educative attributes of textbooks

Educative curriculum materials (ECM) promote teacher learning in more than one way (Davis & Krajcik, 2005) and help teachers combine new specific (pedagogical approaches to use) and general ideas (rationale for using a specific pedagogical approach) to their knowledge repertoires. Curriculum materials can possibly play a crucial role in shaping teachers' instruction and knowledge (Hill & Charalambous, 2012). At the same time, ECM may impede teacher learning because learning on the ECM solely lies on the teachers' beliefs and attitude about the ECM (Davis & Krajcik, 2005). Therefore, Davis and Krajcik (2005) attest that a teacher must use more than one curriculum material (textbook) as a resource to promote learning and, the quality of content and pedagogy.

Drake et al. (2014) agree with Arias et al. (2016) that elementary school teachers are responsible for teaching multiple subjects and therefore must be competent to teach each one of them. Drake et al. (2014) further agree with Arias et al. (2016) that the development of Educative Curriculum Materials (ECM) could assist teachers learn to teach better. Additionally, Schneider et al. (2000) extended the definition of ECMs by arguing that, ECMs are CMs that are designed to address both teacher and student learning. They argue that it is one "vehicle" that could assist teachers learn new methods and content to enact reform-based teaching and consequently improve performance, therefore, ECMs should be constructed in such a way that teachers' knowledge is enhanced and assisted in developing general knowledge that may not necessarily be used immediately, but later in the field (Davis & Krajcik, 2005). This is what Ball et al. (2005) referred to as the knowledge of the horizon and is discussed at the beginning of the chapter. This study relates to textbooks as one form of curriculum materials.

Although this study concerns itself with teachers-in-practice, it deemed fit to review literature on how prospective teachers can be supported by the textbooks regardless of the stance the teacher currently holds because in any case, teachers are also lifelong learners. Solmaz (2017) defines lifelong learning as the learning that people undergo intentionally throughout their lives for personal and professional growth to enhance the quality of their lives.

Therefore, Drake et al. (2014) contend that there are two conceptual examples of the way CMs could be used to support prospective teachers in developing the knowledge required for teaching, namely, **framework for analysing teaching** and **professional noticing of children's mathematical thinking**. These two conceptual examples are linked to KCT and KCS respectively of the MKT framework used in this study. According to Hiebert, Morris, Berk and Jansen (2007) and Morris, Hiebert and Spitzer (2009), the first conceptual example (framework for analysing teaching) is rooted in the acquisition of four key skills of which I have linked each to the stages of LS , namely, setting goals for students (diagnose a problem and plan a lesson); assessing whether goals were achieved as planned during enactment (lesson presentation/observation in LS); hypothesising the possible reasons for the way the lesson went (reflecting on the lesson in LS) and using the hypothesis to modify the lesson (use the ideas that emerged during reflection to strengthen and modify the lesson).

The second conceptual example (professional noticing of children's mathematical thinking) concerns itself with the impromptu decision that a teacher must take in the classroom to respond to children's mathematical thinking (Jacobs, Lamb & Phillip, 2010). They posit that this decision needs expertise of three interrelated skills, namely, attending to children's strategy; interpreting children's understanding and deciding on the approach to use in response to children's understanding (Jacobs, Lamb & Phillip, 2010). Therefore, I concur with the way Drake et al.'s two conceptual examples of the way curriculum materials could be used to assist prospective teachers develop the knowledge required for teaching because they fit like a puzzle with the PCK sub-domains namely, KCS and KCT under mathematical knowledge for teaching (MKT) framework used in this study.

While curriculum materials assist teachers attain multiple knowledge basis needed for teaching (Drake et al., 2014), teachers' knowledge, experience, orientations, and context influence the way teachers instruct students using curriculum materials (Biggers et al., 2013). Davis and Palincsar (2015) concur with Drake et al. (2014) by also asserting that ECM support elementary teachers in supporting students through scaffolding. On the other hand, Neuman et al. (2014) argued that potential teacher learning occurs if textbooks are accompanied by the teacher guides that considers learners' ideas.

Sherin and Drake (2004) posit that during reading, teachers read the curriculum materials for "big ideas", lesson details, examine main activities in the lesson and examine new vocabulary to be introduced in the lesson prior to instruction. When teachers evaluate the text, they consider their own understanding of conceptual connections among the activities selected to be used in the lesson before instruction; consider learners' understanding of mathematical concepts during lesson planning and lesson enactment and consider whether lesson objectives were met, or learners need revision after enactment (Sherin & Drake, 2004). The question is, do teachers with a shaky mathematical knowledge base manage to read text for "big ideas" if they work in silos?

Henceforth, Davis (2009) examined the influence of reading and planning from two different mathematics textbooks, organised differently, using prospective high school mathematics teachers' PCK and content knowledge of exponential functions. Findings revealed that teachers found one textbook to be more beneficial in improving their content knowledge while the other one was more beneficial in improving their PCK. Furthermore, Davis (2009) attests that teachers' learning was influenced by their personal experiences,

e.g., previous textbook experience as well as the quality of the textbook e.g., the way the textbook is organised.

In addition, Watson, and Barton (2011) argue that teachers' fluency with mathematical content forms the platform of the unique contribution of providing knowledge during lesson planning that the textbook and or website could not provide. Therefore, they concur with Stein, Remillard and Smith (2007) that teachers' mathematical content knowledge (CCK) has an influence on how they (teachers) engage with the textbook. Venkat and Spaull (2015) analysed SACMEQ 2007 results of mathematics teachers' data that was tested on 401 Grade 6 mathematics teachers from primary schools in SA. They found that 79% (about 317 mathematics teachers) of the Grade 6 teachers demonstrated content knowledge levels that were below Grade 6 or 7 band. This then indicates that for improved learner performance in mathematics, robust forms of in-service professional development that are collaborative in nature and driven by teacher-needs, need to be in place. In view of this assertion, LS has been proven to be the teaching model that afford teachers an opportunity to drive the PD session while being developed in SCK and PCK in one way or the other in countries worldwide. However, if teachers are performing below expected levels as the findings of SACMEQ 2007 reveal and the resource that they use for lesson planning is the textbook, it is evident that textbooks need to assist teachers develop both SCK and PCK during *kyozai-kenyu.*

Unlike other countries, textbook development in China is taken as a profession and therefore, personnel in the profession gain experience over the years (Li, Zhang & Ma, 2009). According to Li et al. (2009), Chinese mathematics teachers teach using the textbook with fidelity but still register good learner performance in international studies. This confirms that if the educative features of the textbook are on par with the breadth and the depth of the standard curriculum in terms of the content and pedagogy, quality learning and teaching takes place.

3.3.4 Teacher – textbook relationship

Researchers such as Freeman et al. (1983), Brown (2011), Remillard and Bryans (2004), Remillard (2005), Lester (2007) and Lepik (2015), studied teachers' use of interaction or engagement with textbooks. Although they discovered varied ways in which teachers engaged with textbooks, some of their findings overlapped. Lepik (2015) explored teachers' approach to mathematics textbook use in lower secondary schools in Estonia.

Data collection was informed by the researchers' interaction with the sample that consisted of 164 teachers and 29 classroom observations. Lepik (2015) contends that teachers' use of textbooks begins with the choice that they must make between the different series and versions of textbooks that are presented before them informed by the individual teacher's instructional style. Findings revealed that Estonian teachers strongly rely on textbooks for lesson planning but are however not influenced by the teaching approach presented in the textbook, but rather have autonomy to orchestrate their own teaching approach. However, the level of autonomy was found to be directly related to the teaching experience, that is, teachers who are more experienced tended to have a high level of autonomy to orchestrate their own teaching approach compared to teachers who are less experienced. In addition, Lepik (2015) found that text in the textbooks was used sparingly by teachers translating to very low levels of *content literacy*. According to Lepik (2015), learners were perceived as incapable of individually coping with text in the textbook. Lepik's study also revealed that while textbooks were used as a basic instructional tool, they were not used to their [textbooks'] full potential because learners were made to use them *as exercise books,* i.e., textbooks providing only practice exercises for learners and not knowledge and learning opportunities. This contradicts the assertion by Li et al. (2009) that learners should basically learn from the textbook during instruction.

Nicol and Crespo (2006) presented a hierarchical model of mathematics teacher use of a textbook. This model comprised of three levels namely, *adhering*, *elaborating*, and *creating*. According to Nicol and Crespo (2006), *adhering* refers to teachers considering textbooks as "an authority" that dictates what to teach and how to teach it. As a result, teachers at the adhering level make no or few modifications or adjustments to the textbook tasks and demonstrate superficial changes in teaching. *Elaborating* refers to teachers that consider textbooks as "a guidance" that also tells them what to teach and how to teach it but, at this level, teachers also use other sources to modify tasks in the textbook (Nicol & Crespo, 2006). *Creating* involves critical and innovative use of a textbook aiming at understanding the authors' intention for the textbook and the limitations thereof (Nicol & Crespo, 2006). Nicol and Crespo (2006) attest that at the creating level, teachers can enhance their teaching by designing appropriate tasks for their learners. Furthermore, Nicol and Crespo (2006) assert that textbook utilisation in a lesson varies

depending on the level of lesson presentation that the teacher is at for example, deepening learners' understanding of the concept, solving problems or summarising.

Freeman et al. (1983) conducted a case study investigating how content is determined in the grade using seven teachers. Freeman et al. (1983) found that there were four styles that teachers used to cover the curriculum with reference to textbook use. These four styles of teachers' textbook use were later highlighted by Lester (2007). In no specific order these styles are *textbook bound, selective omission, basics focussed* and *management by objectives.* Textbook bound refers to the teacher who teaches solely by using the textbook, following it page by page. Selective omission is almost similar to textbook bound however in this case the teacher skips some chapters or topics probably because they are not *au fait* with them. *Basics focussed* refers to teachers that selectively used the textbook to teach the fundamentals of mathematics. Lastly, *management by objectives* refers to using the textbook as a tool to achieve the objectives stipulated in the policy or by the district.

Reflecting from the way teachers use the curriculum in the previous paragraph, *textbook bound,* implies that the teaching and learning is rigid, teacher-centred approach, learning is not related to meaningful context, what is in the textbook stands and is correct and cannot be questioned. However, textbook-bound teachers may improve their CCK and SCK sub-domains but limited improvement (if any at all) from the PCK because teaching and learning is teacher-centred. With *selective omission*, implications are that learners are not taught the set curriculum for the grade and will be promoted to the next grade with content gaps especially since there is progression in the topics within the mathematics discipline across the grades. *Basics focussed* is like selective omission in the sense that there are topics that are taught, and some not taught. Maybe, textbooks that have educative features that would assist teachers to learn the omitted topics could be of great assistance. *Management by objective* focusses on just achieving the policy objectives. None of the above textbook use strategies focusses on learner understanding of concepts.

Moreover, Brown (2011) investigated how science teachers used a standards-based curriculum. Three different ways in which teachers used the curriculum were identified as namely, *offloading*, *adapting, or improvising.* According to Brown (2011), *offloading* refers to teachers following the curriculum as expected; *adapting* refers to teachers selecting

tasks from the curriculum material but adapts them to suit their (teacher's) preference and need and lastly, *improvising* refers to teachers substantially shifting from set curriculum suggestions and rather designing their own curriculum structure.

Having outlined the different ways teachers use the curriculum, *offloading* the curriculum from the teacher to the learner could imply that the teacher does not understand the concept well, teaching is teacher-centred, learners are passive recipients of knowledge, imparted knowledge may not make sense to the recipients and or even to a certain extent-the teacher as well, learners rote learn procedures and cognitive demand of selected tasks are of low levels. A teacher that *adapts* the curriculum to me is at a higher level in terms of MKT compared to the one that offloads. This means the teacher can make sense of the work that he/she is going to present in class. A teacher that *improvises* has an improved level of MKT and therefore his/her learners will make better sense of their learning than the first and the latter one,

In a similar study, Remillard and Bryans (2004) studied eight elementary school teachers over a period of two years on how they used the same lesson with regard to textbook use. Data was collected through interviews and observations. According to Remillard and Bryans (2004), analysis was done based on the thoroughness and the extent at which teachers used the curriculum structure, mathematical content, educative features, and pedagogical suggestions contained in the textbook. Findings revealed that two teachers used the curriculum *narrowly and intermittently* – they were dependant mostly on their routines and the curriculum material that they had developed and used over years. When using the standard-based curriculum that was adopted at their school they selected tasks that seemed familiar so that they could align them with the repertoires of curriculum materials that they had developed over years. The next two teachers *adopted and adapted* the curriculum, that is, teachers adopted tasks from the textbook but also adapted them to suit their own strategies and approaches during enactment. The last four teachers were seen to be *thorough piloting* the curriculum. Here, teachers used the curriculum material as their guide, they read the contents of the curriculum guide thoroughly and attempted to follow the lesson as suggested.

Teachers that use the curriculum *narrowly and intermittently* could have implications of them (teachers) going to class without proper planning, giving learners previous years' assessments which, they (learners) may have and produce results that are unreliable

while reporting wrong results to the parents and every other stakeholder in the education system. The uniqueness of learners' learning styles in the pedagogy once again is not considered. The two teachers that *adopted and adapted* the curriculum to suit their own approaches surely did consider their learners' learning styles (KCT) and their learners' thinking (KCS). This also means their SCK and CCK was at expected levels because if teachers lack in CCK and SCK, they will find it challenging to adapt activities from the textbook. Teachers that *thoroughly piloted* the curriculum taught for compliance but not to effect teaching and learning.

Furthermore, Remillard (2005) presents four approaches to teacher's use of mathematics curriculum material namely curriculum use as, *following*, *subverting*, *interpretation,* and *participation with*. She argues that researchers that concern themselves with teachers' use of curriculum material as following or subverting view curriculum materials as a "as embodying discernible and complete images of practice" (p. 343) and therefore focus on the extent with which teachers *follow or subvert* the curriculum. Remillard (2005) refers to *following* as teaching using the textbook with fidelity. On this approach, researchers concern themselves with how clearly the writers of curriculum materials can be to properly guide the teacher (Remillard, 2005). Cases of teachers that use the curriculum by following teach what is in the textbook with fidelity but in the case of subverting teachers, they teach following the textbook by selecting, altering, and transforming tasks to suit the conventional structures of classroom teaching and management (Remillard, 2005). However, she continues to argue that researchers have found more teachers subvert than follow the curriculum. In addition, Lester (2007) asserts that Lambdin and Preston found that teachers' confidence in their mathematical knowledge was the determining factor of how they would be classified. Jamieson-Proctor and Byrne (2008) attest that, teachers who are less confident in their mathematical knowledge tend to teach by following the textbook with fidelity because they trust the textbook author's program over theirs. According to Remillard (2005), cases of subverting teachers normally voiced out the need for simpler and clearer curriculum materials and enhanced professional development programs. Could this be due to issues of confidence informed by the teachers' mathematical knowledge?

Evidently so, if teachers quest for more informative, comprehensive, simpler, and educative curriculum materials (specifically textbooks) accompanied by professional development programs, it means they see a gap that needs to be narrowed. I want to

believe that teachers will favour a textbook that they learn from. When they *subvert*, in terms of altering, experience has shown me that they alter and transform task to be less cognitively demanding producing a learner who is not competent to standardised assessments. The implications of teachers that teach the curriculum by *following* the textbook with fidelity would have the same implications as the one who is *textbook bound.*

The use of curriculum materials as *interpreting* researchers according to Remillard (2005) concerns themselves with the kind of interpretations teachers make, factors that influence these interpretations as well as classroom practice that emerge because of these interpretations. The view of curriculum use as interpretation of text could be facilitated by the educative features (EF) in the curriculum materials that teachers must read, understand, critique, evaluate and adapt (Remillard, 2005). Researchers acknowledge that teachers have experience and beliefs that they use to interpret text in the textbook so that the text makes meaning to them and how the meaning making process shape the implemented curriculum. (Remillard, 2005). However, due to teachers' different beliefs, experiences, and attitudes to teaching, there are variations in the manner that curriculum use is interpreted (Remillard, 2005). In this study, the variations that emerge because of the different beliefs, experiences, and attitude to teaching that teacher may have been narrowed down by having a group of them collaboratively planning a lesson. They would deliberate until they arrive at one understanding.

Curriculum use as *participating with* is the fourth perspective that researchers use to view the teachers and curriculum material on the teacher-text relationship (Remillard, 2005). Remillard (2005) contends that there is a significant overlap between curriculum use as *participating with* and as *interpreting* however, the difference is the interest in studying the nature of the participatory relationship. According to Lester (2007) researchers of this perspective concern themselves with the way certain features of the curriculum resource gels with the teachers' interpretation of the feature to shape the implemented curriculum. Lester (2007) attests that while researchers under this perspective acknowledges the dynamic interrelationship between the teacher and the text, they also have an interest on the complexities of text transformation from written curriculum (partially implemented curriculum) to implemented curriculum.

From the assertions above, there are similarities in the concepts depicted by Remillard (2005) and Brown (2011) in the way teachers use the curriculum materials (see Table 1).

These concepts were used interchangeably based on the phenomenon (how teachers used the textbooks) observed during collaborative lesson planning and lesson presentation.

Table 1: Modes of teachers-textbook engagement

Remillard (2005)	**Brown (2011)**
Offloading	Following
	Subverting
Adapting	Interpreting
Improvising	Participating with

Lester (2007) contends that teachers tend to be selective in terms of which component of the curriculum needs to be emphasised depending on their knowledge of the content. On the other hand, Stein, and Kaufman (2010) posit that teachers' use of curriculum during lesson planning could be defined as non-mathematical (focuses on structural outline of the lesson only); materials needed for lesson (teaching aids to use in the lesson) and big mathematical ideas (teacher talk about lesson beyond the basis activities of the lesson and pronounce concepts and ideas that are within the lesson). The latter use of curriculum by Stein and Kaufman (2010) corresponds to *interpretation* and *participating with* the curriculum phase outlined by Remillard (2005).

Stein, Remillard and Smith, (2007) on the other hand argue that there are several factors that contribute to how teachers engage with the curriculum material (textbooks), such as, classroom control and management; teachers' professional identity; teachers' mathematical content knowledge and teachers' perception of a textbook. Herbel-Eisenmann and Wagner (2007) argue that it is imperative to 'interrogate' the curriculum material to investigate teachers' use of it. The usage of the same textbook in schools does not translate to the same teacher instruction because it is the teacher that orchestrates learning and therefore mediates or controls the "what", "when", "how" a textbook can be used by both the teacher and the learner (Lepik et al., 2015). This study is contextualised by LS and therefore, deviations in the way the lesson is orchestrated is minimised because the lesson is collaboratively planned by teachers.

This study is about *kyozai-kenyu* (study of curriculum materials in particular textbooks) and according to Huang and Shimizu (2016) as cited in the purpose of my study (see section 4), teacher involvement in *kyozai-kenkyu* is the most important part of lesson

planning in the LS cycle. Therefore, although Lester's (2007) perspectives of teacher engagement with textbooks is not in the context of LS, it still falls under *kyozai-kenkyu* since teachers are engaging with textbooks.

Fan, Chen, Zhu, Qui, and Hui (2004) investigated how teachers and learners used textbooks within and beyond the mathematics classroom in China. However, directed by the focus of this study, the review will focus and report on the use of textbooks by the teachers. Data was collected through questionnaires, classroom observations, and interviews from 36 mathematics teachers and 272 learners in 12 secondary schools. Several series of textbooks for the respective grades had been approved by the Ministry of Education in China and were all being used (Fan et al., 2004). Findings revealed that more teachers from low performing schools followed the sequence in the textbook more than teachers from high performing schools. For teachers that did not often use activities from the book, they argued that they were catering for more challenging tasks and took activities from previous years' question papers but guided by the order of the textbook (Fan et al., 2004). In addition, findings revealed that teachers used textbooks while planning the lesson more frequently amongst all teaching material for advances on content and decisions on approaches to use to enact the lesson. Furthermore, teachers also revealed that they used textbooks to select examples to use in class, in-class activities as well as homework (or drill) activities from the textbooks during their lesson planning. Findings also revealed that some teachers selected problems for learners to read some text in class and or at home. However, four teachers revealed that their use of textbooks changed over time (they were less dependent on textbooks) because they believed that learning through self-discovery can assist learners understand mathematical concepts better (Fan et al., 2004). They assert that this is due to several reasons namely, growth of teaching experience and familiarity with the textbook, teachers own reflections of their teaching and learner performance, and focus on quality learning.

According to Leshota (2020), pedagogical design capacity is not only about the "degree of appropriation" that curricular resources afford for the teacher; but it is also about the quality of learning opportunities that teachers create for learners. Leshota (2020) distinguished between two types of teacher-textbook relationship, *omissions,* and *injections* to indicate teachers' quality of PDC. While *omissions* refer to the content that is available in the textbook but for some reason, teachers choose to leave out during lesson presentation, *injection* refers to the content that teachers add during lesson

presentation that was not originally there in the textbook (Leshota, 2020). Important to note is, before a lesson is presented, it is planned. So, even though Leshota (2020) focuses on lesson presentation, lesson planning is implied, and this study's focus is on both the lesson planning and the lesson presentation stages of the LS cycle. Leshota (2020) further distinguishes between different types of *omissions* and *injections*. *Productive omissions* are those omissions that do not detract the mediation of a lesson and *critical omissions* are those omissions that detract the mediation of a lesson but are critical for mediation (Leshota, 2020). *Robust injections* are injections which foster the mediation of the concept and *distractive injection* are injections that detract the mediation of a lesson. So, using Leshota's (2020) assertion above the SACMEQ 2007 results that depicted that Grade 6 mathematics teachers seemed to have some content gaps, I argue that them (teachers) omitting or injecting content during lesson planning and lesson presentation could detract the implementation of the intended curriculum.

In the first paragraph of this section, I argued that teacher-textbook relationship is respectively a dependent-independent relationship. Fan et al.'s (2004) investigation discussed in the previous paragraph reveals that with more teaching experience in the subject, familiarity with the textbook(s), teacher reflection on their own practice and a focus on quality learning, the relationship status changes. Teachers do not depend more on textbooks for enactment, the relationship becomes loose as they prefer self-discovery approaches to teaching. This would gel well with curriculum use by participating with and or interpreting by Brown (2011), adapting, and improvising by Remillard (2005) as well as adopting and adapting by Remillard and Bryans (2004). Teachers that would have reached this stage are teachers whose MKT would have reached the expected levels because in their deliberation, they would cover all the sub-domains of the MKT framework.

3.3.5 Teacher-textbook relationship during lesson planning

Mathematics textbooks equally serve two purposes namely, as a resource for learners to learn and as a resource for teachers to use during lesson planning and lesson enactment (Lepik, 2015). Estes, McDuffie, and Tate (2014) use a metaphor of lesson planning to plan a road trip where, a map leading to the destination represents the CCSSM (policy), the mode of transport represented by the textbooks as a resource and the desired destination represented by learners engaging in cognitively demanding tasks and linking

their learning to the world around them. They categorise the stages of the journey into four phases namely, lesson goals, topic progression, student perspective and task selection. Under lesson goals, they focus on “What should students be able to see and do when we arrive at our destination?” (p. 207). To determine goals, Estes et al., (2014) assert that they had to firstly, **choose a destination** and that they did by consulting the CCSSM to check for the parameters and the assessment on the textbook to be sure of what learners needed to be able to do. Secondly, **connecting routes** – connecting the lesson and the learning to other mathematical concepts and processes, other disciplines, and everyday life. Thirdly, **road conditions** – consideration of all cognitive levels in selected tasks. Fourthly, **local attraction** – use the above processes to arrive at the lesson goal that informed lesson instruction and lastly, **speak the dialect** – used a textbook to ensure that the terms and vocabulary used in the lesson is the universal one.

Phase two – topic progression concerns itself with the prerequisite knowledge, concepts, and procedures that learners need to have to take off with the current lesson (Estes et al., 2014). According to Estes et al. (2014), the information on learners’ prior knowledge on the lesson was obtained from surfing the Common Core State Standards. Activities that would enable highflyers to cognitively engage in the lesson were also selected (Estes et al., 2014). “How do I help students move down the learning road?” (p.209) is phase three of lesson planning (student perspective) where Estes et al. planned on different teaching approaches to assist learners achieve the learning goal informed by individual learner needs for example, learners with misconceptions, learners with language barriers, learners who are conceptually ready to move etc. Lastly, phase four - “How do we decide on the best vehicle to drive to our destination?” (p.209) concerns itself with the selection of the best suitable task for the learners to achieve the learning goals (Estes et al., 2014). Furthermore, Estes et al., (2014) contend that teachers should select task (vehicle) with context that is familiar to their learners for the destination to be reached.

In line with Estes et al.’s assertions above, Stein, Engle, Smith, and Hughes (2015) attest that there are five practices for orchestrating productive mathematics discussion in the classroom. My assertion is that the following practices proposed by Stein et al. (2015) should feature in the lesson plan before they can permeate the lesson presentation and furthermore, I align each practice with the sub-domains of the MKT framework used in this study. These practices are setting goals and selecting task – KCS, KCT, SCK and HCK; **anticipating** learners’ responses and their thinking to mathematics problems –

SCK, KCT and KCS; **monitoring** learners' individual work during enactment – SCK and KCS; **selecting** examples of learners' work that will enforce the goals of the lesson - SCK; **sequencing** the examples to arrive at the desired goal and making **connections** – SCK, KCT using ideas across the examples. They refer to these practices as 5 (+ 2) because there are two other processes that take place before the stage of anticipation, *namely*, **setting goals** and **selecting tasks** – SCK, KCC, KCT and KCS. All these five practices including the embedded two are inclusive during the lesson planning (*kyozai-kenkyu*) and lesson presentation stage of the South African LS cycle. Moreover, the descriptions of the 5 (+ 2) domains fit with the descriptions of the MKT domain as illustrated above. Therefore, data collected during lesson planning and lesson presentation will be characterised by these domains.

Concurring with both assertions above, Stein et al. (2015) posits that setting goals entails teachers' understanding of what learners need to know and understanding about mathematics content in a mathematics lesson, being specific to set clear targets for instruction that can assist in the selection of instructional activities while mindful of the use of the five practices mentioned above. The process of selecting or designing tasks involves identifying a mathematical task that is aligned with the goals of the lesson and ensuring that the selected task supports cognitively challenging discussions (Smith, & Stein, 2018). They assert that the above two practices will be supported by *firstly*; teachers' consideration of what learners will know and understand during enactment rather than what they will do; *secondly*, teachers' using resources to assist learners unpack big ideas in mathematics and *thirdly*, teachers working in collaboration with one another. They argue that the process of anticipating learners' responses to mathematics problems and their thinking involves the teachers' consideration of the different strategies that learners may use to tackle and solve the task at hand and how best to respond to their possible concerns and questions pertaining to the problem as well as teachers' consideration of which method or strategy will be most suitable to address the mathematics to be learnt. Stein et al. (2015) attest that this process will be supported by teachers doing the selected mathematics problems using different approaches; discussing the problem with other teachers; possibly making inferences on relevant research on the topic, if necessary, for discussion and documenting learners' responses, concerns, and misconceptions each year for utilisation during lesson presentation of the same topic the following year.

On the other hand, Choy (2014) investigated what six mathematics teachers notice about learners' mathematical reasoning during the lesson planning on fractions of 10-year-old primary school learners in Singapore in the context of LS. He describes teachers' productive mathematical noticing using LI and Huang's (2012) Three-point framework which is characterised by the *key point* (key mathematical idea or concept of the lesson); *difficult point* (difficulties encountered by learners to learn the key point); and *critical point* (the approach the teacher takes to assist learners overcome the difficult point). With reference tasks that teachers selected from the textbook, Choy (2014) highlights that less teachers' productive noticing was evident where noticing was specified but not supported by reasoning and justification. According to Choy (2014), teachers' productive mathematical noticing is evident when teachers can:

- give attention to specific detail that addresses the key point, the difficult point and the critical point that has the potential of producing new responses during lesson planning.
- relate these details to prior knowledge and experiences to gain new insight on instruction especially pertaining to the key point and the difficult point.
- use the new insight and understanding to decide on how to respond to instructional actions – critical point.

Consideration of different learners' thinking implies consideration of different types of questions and questioning and therefore different cognitive levels are imperative during lesson planning. Lambert and Stylianou (2013) pose a question of whether learners who struggle with mathematics would benefit from cognitively demanding tasks the same as those learners who do not struggle? They stress that learners have different learning abilities and so, a lesson should be structured in such a way that it is inclusive pertaining to teaching for conceptual understating. Lessons should embrace diverse learning; present multiple means of representation; multiple means of engagement; multiple means of strategic action (Lambert & Stylianou, 2013).

Since LS is a relatively newly introduced teacher development model in SA, its [LS] implementation has not permeated all the teachers and structures the same. As a result, there has been limited research on mathematics teacher utilisation of textbooks during collaborative lesson planning therefore, this study will then contribute to the body of knowledge in this field.

3.3.6 Teacher-textbook relationship during lesson presentation

While textbooks play an important role in developing effective classroom instruction and teachers' mathematical knowledge, they [textbooks] also "should arouse students' interest in learning mathematics, help students to study mathematics actively, develop students' potential in creativity through the process of learning basic knowledge, improve students' mathematical thinking when trying to understand the essence of mathematics knowledge, and raise students' awareness to apply mathematics knowledge in everyday lives" (Li, Zhang & Ma, 2009, p. 743). However, it is the teacher who mediates and directs learners' use of textbooks during enactment (Lepik, 2015). Danışman (2019) asserts that teachers use of textbooks in the classroom is mainly for the purpose of giving homework.

Aineamani and Naicker (2014) investigated the effectiveness of the mathematics textbooks in developing learners' understanding and motivation for the subject by studying Pearson's mathematics textbooks. Findings were framed by Kilpatrick's' five strands of mathematical proficiency and the Variation theory. They concluded that textbooks used in the classroom impact on how learners view mathematics and therefore ensure or limit learners' communication of their mathematical ideas.

Magayon and Tan (2017) in the Philippines conducted a study to contribute to the understanding of the practical implementation of curriculum differentiation. Six grade 7 mathematics textbooks were used to gather data using priori codes under Qualitative Content Analysis. Textbooks in the Philippines are the basic resource that teachers use to teach mathematics (Magayon & Tan, 2017). Findings reveals that textbooks provided the same type of differentiation but differed in the extent or the level of differentiation. Life situations, abstraction and proof of reasoning were found to be the most common types of differentiation in all six textbooks. Magayon and Tan (2017) conclude that although differentiation is catered for the introduction and presentation of the lesson for the teacher to teach, learner activities in the textbook as well as tests do not accommodate all learner's learning styles and still need to be modified.

One integral part of mathematics education is problem solving. Teachers solve problems during lesson planning which are in turn solve by learners during lesson presentation. Liljedahl, Santos-Trigo, Malaspina, and Bruder (2016) attest that mathematics problem solving is a significant aspect of mathematics, mathematics teaching and mathematics learning. According to Liljedahl (2008), problems are tasks or activities that cannot be

solved procedurally with minimal effort but rather, will require some creative insight to solve. The infusion of problem solving in the mathematics curricula around the world resulted in teaching through problem solving as well as teaching problem solving (Liljedahl et al., 2016). This study did not teach through problem solving but taught problem solving. Mathematics activities are significant elements that can be used to engage learners in higher order mathematical reasoning (Liljedahl et al., 2016).

3.3.7 Teacher Professional Development

There have been numerous teacher intervention programmes that are directed by different educational structures, led by external personnel to the school environment but, proven to be less effective. In this section, I discuss what different scholars regard as the effective way of teacher development, and affordances of LS as a model of teacher professional development.

3.3.7.1 Effective professional development

Lesson study as the model of teacher's professional development as discussed in the previous chapter, constitutes a platform under which this study is located. This section discusses literature on effective teacher professional development and highlights the prospective gaps between the current model of intervention as I have experienced as a district official and Lesson Study. Since this study is contextualised by LS, affordances of LS are also discussed.

Darling-Hammond, Hyler and Gardner (2017) assert that effective professional development is "structured professional learning that results in changes in teacher practices and improvements in student learning outcomes" (p 2). Professional learning is conceptualised by these authors as learning that is provided externally to teachers as well as activities that take place within the context of job structure that help teachers change their instructional practice and increase their mathematical knowledge in ways that foster student learning.

A large percentage of teacher PD programs in SA is dominated by activities that do not focus on pedagogy and methodology to teach the content (Nel, Luneta, 2017). Nel and Luneta (2017) attest that a teacher PD program that uses mentoring (most experienced teacher mentoring the least experienced teacher) as one of the interventions while

incorporating teachers' content and instructional needs enhances lesson preparation, understanding of mathematics and teaching skills. In addition, Postholm (2018) contends that schools could conduct needs assessment to identify teachers' needs and inform interventions for professional learning, the state and district officials could identify and develop expert teachers as mentors and coaches to use their expertise to support teachers in different locations within the district, state and district officials can integrate teachers' professional learning with the schools. According to Darling-Hammond and Richardson (2009), the most useful PD is the one that focusses on teachers' active participation and hands-on experience as compared to abstract discussions.

Darling-Hammond, Hyler and Gardner (2017) identified seven features of effective PD that has proven to improve teachers' mathematical knowledge and change their instructional practices while, simultaneously improving learner performance. These features include PD that: is **content focussed** (focussing on teaching strategies of a specific content improves teacher learning and teaching methods), **incorporates active learning** (actively engages teachers to design learning strategies that they want to discern in their classrooms while experiencing them themselves – first hand) , **support collaboration** (create space for teachers to share ideas and work collaboratively in their learning within school contexts), **uses models of effective practice** (teachers viewing models such as lesson plans, units plans, observation of peer teachers etc for them to clearly understand what best practices entail), **provides coaching and expert support** (individual teachers' needs on content shared and addressed by expertise), **offers feedback** (teachers afforded time to reflect on their practice for them to move towards the expected vision of practice) and **reflection and is of sustained duration** (teachers afforded time to learn. practice, implement and reflect on new strategies that bring about change in their practice).

Martherson and Windle (2017) conducted research on: what do teachers want from their PD? Four themes emerged revealing that teachers want PD learning opportunities that: (a) are interactive, engaging, and relevant for the learners they teach (b) show them a more practical way to deliver content (c) are teacher-driven and (d) sustained over time. Therefore, teacher-based, and teacher-driven professional development programmes are imperative to improve learners' performance through improving teacher competency in teaching subject content in a way that enables a learner to understand, apply knowledge

and reason. Hence, it is imperative for textbook activities to cater for a variety of questioning styles.

3.3.7.2 Affordances of Lesson Study for effective professional development

This study was conducted under the context of LS as a form of professional development. The topic for this study is: Mathematics teacher's engagement with textbooks: the affordances of Lesson Study. Murata (2011) contends that the distinctive features that distinguish LS from other professional development approaches are the research lessons, and the rest of the LS cycle stages that follow. Collaborative lesson planning and the debriefing sessions promote teacher learning because they allow teachers firstly, to strengthen their skills of noticing evidence of learners' learning and secondly, to collectively gain PCK (Dudley, 2014). Lee and Tan (2019) posit that some affordances of LS are: *collegial questioning and critique* (teachers share concerns, question assumptions and are comfortable to examine and critique their practice), *rehearsal of stimulus activities* (teachers identify errors and misconceptions that learners may have or have and come up with strategies to prevent them from recurring), *multimodal representation and juxtaposition of students' work* (teachers discuss different representation and calculation strategies of the same problem), *collaborative improvement of lesson activities* (during lesson reflection, everybody's input is valued so as to strengthen the lesson) and, *simultaneous attention to student learning and teacher learning* (teachers are mindful of their professional learning goals and learners' learning goals as they learn about learners' learning instead of just thinking what to teach). Lee and Tan (2019) further assert that professional learning is the sum of the collection of learners learning data through lesson observation and collective enquiry of teachers' classroom practice through lesson reflection.

So, there has been a gap between the teachers' needs and the intervention programmes thereof. The interventions do not really address the needs of the teachers in totality. Evidently, professional development is multidimensional and dynamic and therefore can no longer be confined to a kind of a "lecture" content workshop that we conduct as subject advisors to teachers. Experience has proven that these workshops are less impactful because learner performance in mathematics has not significantly improved over the years. However, the repeated cycle of LS enables teachers to experience the iterative process which has been proven (in many countries) to improve learner performance.

Schipper, Goei, de Vries, and van Veen (2017) attest that not only does LS promote adaptive teaching competence that results in the enhancement of teacher professional growth but, intensive focus on student learning, collaborative lesson planning, lesson presentation and lesson reflection also exposes teachers to some level of professional growth. The processes of LS are in line with what scholars have proven to be a successful or effective form of professional development. Furthermore, what Martherson and Windle (2017) found to be the teachers' needs in a PD session, is covered by the LS model of PD. Having implemented LS for one year in my district, I can attest to the same effects regarding teacher PD.

3.4 Conclusion

In conclusion, it is evident that the mode of teacher-text engagement that teachers use as they collaboratively plan and present lessons whether in the context of Lesson Study or not, are directly impacted by the MKT that they possess. Although teachers' MKT level can be enhanced through professional development session that are teacher needs driven, the educative feature of textbooks, also assist teachers execute their work qualitatively. Using the context of patterns, I attest that for the *Input* (intended curriculum - CAPS) to yield quality *Output* (enacted curriculum), there is a lot that must go on in the *Process* (potentially implemented curriculum – textbook). The process entails proper screening of textbooks to ensure close alignment of the intended and the potentially implemented curriculum, textbooks that assist the teacher to learn and teach and the learner to learn, training of teachers on the intended curriculum, teachers allowed to use different textbooks as a resource, and supported LS practices.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

Whenever data are to be collected, there needs to be an explicit plan on how the process will be done. Mohajan (2018) views research methodology as a specific, disciplined, and explicit plan that guides the data collection process of the study to respond to the research questions. This study explored how Grade 6 mathematics teachers engage with the textbook in the context of LS. This chapter, therefore, delineates and explains the systematic approach to structuring a research methodology informed by Saunders, Lewis, and Thornhill's (2009) *research onion*. Saunders et al. (2009) assert that there are six layers to their *research onion,* which are: philosophical assumption, methodological choice, research approach, research strategy, time horizon and research techniques and procedures. Informed by this assertion, I start by firstly presenting the philosophical assumption that frames the study, followed by the methodological choice aligned to it. I further discuss the research approach used in this study; the research strategy and the time horizon this study covered. Lastly, within the *research onion*, I discuss the research techniques and procedures that this study undertook where I give a brief description of case and the research population and sample. For the research procedures, I outline and discuss the data collection and analyses methods. Other than the key components of the research, I have addressed quality criteria to enhance the trustworthiness/robustness of the findings, and ethical considerations to bolster ethical and morally sound research practices during interaction with the participants.

4.2 Philosophical assumption

Philosophical or paradigmatic assumptions in research are defined as the researcher's philosophical orientation which has significant implications regarding the methodology chosen for the research, methods, and decisions to be made throughout the research process (Kavunja & Kuyini, 2017, Rahi, 2017). A research paradigm informs us how meaning will be constructed from the data that will be collected based on the researcher's experience (Kavunja & Kuyini, 2017). I have adopted the interpretivist paradigm as a philosophical perspective because it concerns itself with deeper meaning and insight on the phenomenon being studied (Creswell, 2017). The nucleus of the interpretivist paradigm is constituted by the researcher's understanding of the individuals' actions

(phenomenon) and the interpretation of the world that surrounds them (context), thus assuming that the world is socially constructed (Kavunja & Kuyini, 2017; Creswell, 2017). Therefore, through the interpretivist paradigm I gained in-depth understanding into mathematics teachers' engagement with the textbooks during Lesson planning and Lesson presentation within the context of Lesson Study. Kavunja and Kuyini (2017) assert that the interpretivist paradigm assumes a *relativist ontology*, a *subjectivist epistemology*, a *balanced axiology,* and a *naturalistic methodology*. *Relativist ontology* refers to an understanding or a belief that the phenomenon being studied has multiple realities, and those realities can be comprehended and be further explored through the interactions among the participants or between the researcher and the participants. This then means that there is no "fixed" reality, thus reality is not absolute. Given this assertion, this study involved a group of teachers as participants, and it was anticipated that that would bring different experiences, practices, contributions, and perceptions on their engagement with the mathematics textbooks(s) during lesson planning and lesson presentation.

Subjective epistemology refers to the belief that the researcher uses the participants' responses and actions and his/her experience in the field of the phenomenon being studied to make sense and meaning of the data gathered (Kavunja & Kuyini, 2017). As a mathematics subject advisor who received training on Lesson Study in Japan, I am well versed with the LS cycle including the two stages that is the focus of my study, namely lesson planning and lesson presentation.

Kavunja and Kuyini (2017) contend that *balanced axiology* assumes that the researcher will embed values in the process of research that will enable him/her to report valuable findings. With reference to this study, ethical issues were observed throughout the process of this study. Detailed ethical considerations are presented in Section 4.11.

Naturalistic methodology refers to the "route" the researcher takes to gather data, knowledge and understanding to respond to the research questions and contribute to the body of knowledge. In addition, according to Creswell (2017), the ontological and epistemological assumptions of the interpretivist paradigm lend themselves to qualitative methodology. For this reason, I adopted a qualitative research methodology to inductively understand the practices, views, and experiences of teachers when they engage with textbooks to plan and present their mathematics lessons. To achieve this, I adopted a case study design and used observations and interviews for data collection from

participants' natural setting, i.e., Lesson Study setting in their schools during collaborative lesson planning and lesson presentation in their classroom.

4.3 Methodological choice

This study adopted a qualitative approach to research. According to Creswell (2014) some of the strengths of qualitative research include: open-ended questioning opens room for new or unanticipated phenomena since it allows people to open up and create new evidence which was not envisaged; in-depth analysis of the phenomenon; has rich and detailed information of the participants; allows the researcher to explore perspectives of a homogenous group. Moreover, Creswell (2014) continues with strengths of qualitative research by attesting that more and new insight is gained through its descriptive and narrative nature; it can contribute to suggesting possible relationships, causes, effect and dynamic processes involved; it offers deeper insights into causes and direction of causal processes; data collection requires a limited number of participants and therefore limited resources – minimal costs; participation methods usually empower participants rather than objectify them.

Furthermore, Choy (2014) posits that in as much as qualitative research has strength, it has some weaknesses too. According to Choy (2014), some of the weaknesses are: it is time consuming; an important issue could be overlooked or unnoticed depending on the researcher's vigilance, experience and competency; participants have more control over the data collected than the researcher; there are a preconceived or finite set of issues to examine; data results are not objectively verifiable; data collection needs skilled interviewers for it to be a success; events, situations, contexts cannot be replicated and therefore generalisations cannot be confidently made to a wider context; the unavoidable presence of the researcher during data collection can negatively affect and influence the participants' response and viewpoint of the researcher and the participants are subject to personal idiosyncrasies biasness.

Qualitative research interests itself with patterns among cases but, however, does not reduce the cases to their averages during analysis (Lune & Berg, 2017). Informed by the above assertions, the following characteristics qualified this study to be qualitative: I needed a detailed and complex understanding of the how teachers engage with the textbook and use the study's findings to respond to the research questions. I, the researcher was the primary instrument (human) for data collection through observations

and interviews; my scope as the researcher was open to any contribution from the participants; the phenomenon being studied (Grade 6 mathematics teacher engagement with the textbook) was descriptive in nature and therefore described social interactions as they occur; the sample size was not too big; data of this study was presented in a narrative form, the study's findings were presented in the form of concepts, categories, themes and were not generalised.

4.4 Research approach

To analyse data, this study adopted an inductive-deductive approach informed by the following assertions. A researcher can use different approaches to analyse content obtained in the field namely, inductive approach, deductive approach, or both (Lune & Berg, 2017). In addition, Lune, and Berg (2017) contend that both inductive and deductive approaches are underpinned by the researcher's experience of the phenomenon. Using both the inductive and the deductive approach in qualitative research to analyse data constitutes a comprehensive approach (Azungah, 2018). Alase (2017) describes inductive approach as "a qualitative research tradition that has the ability to analyse raw data to the objectives of the researchers" (p. 4). According to Lune and Berg (2017), an inductive approach concerns itself with the researcher "immersing" himself/herself into the data presented by participants and analyses it with an aim of identifying patterns/ theme which are subsequently explained by the application of the study's chosen theoretical framework. In addition, the inductive approach enables the researcher to provide in-depth descriptions and interpretations of the participants' everyday experiences in relation to the impact the phenomenon being studied has had on the lives of the participants (Alase, 2017).

In the deductive approach, the researcher goes into the field with some theoretical perspective suggested by the study's theoretical framework to explain cases under investigation and the framework may also be used to generate a hypothesis about the case where the data collected, text and other documents serve as a tool to assess the hypothesis (Lune; Berg, 2017). Nevertheless, Lune and Berg (2017) continue to contend that in many instances, the relationship between the theoretical framework and the phenomenon involves both the inductive and the deductive approach however, for the researcher to get the participants' perspective of the phenomenon – an inductive

approach would have to be used but at the same time, not necessarily excluding the deductive approach.

4.5 Research design

A research design is a method the researcher wants to adopt in conducting the research which is informed by the purpose of the study and the research questions (Yin, 2012). The research design adopted for this study was the case study to explore how Grade 6 mathematics teachers engaged with the textbook(s) in the LS context during Lesson planning and Lesson presentation stages. Creswell (2017) defines a case study as one of the designs appropriate for qualitative approach where a researcher explores a case or multiple case using different data collection techniques and reports thematically. In addition, in line with the research approach discussed in section 4.4, Yin (2012) asserts that a case study design caters for an in-depth enquiry and understanding of the phenomenon and allows for knowledge to be socially constructed.

The justification of adopting a case study emerges from the premise that in this study collaborative lesson planning took place in its "natural setting" because teachers met where they normally meet to collaboratively plan lessons for LS, i.e., the environment was not changed for the purpose of conducting research. For lesson presentation, lessons were taught by teachers to their learners at their schools. Also, the boundaries between lesson planning and lesson presentation in the context of LS or outside the context of LS are "blurred" because lesson planning and lesson presentation is what defines the core duties of the teacher. In addition, Yin (2014) contends that a case study concerns itself with the "how" and the "why" questions. The research questions of this study are in line with Yin's assertion above.

Yin (2014) asserts that a case study enquiry is characterised by multiple sources of evidence with data converging in a triangulating manner; its ability to handle many more variables of interest than data points from a technical point of view, and its ability to guide data collection and analysis through connecting prior developments of theoretical propositions to the case. Considering these assertions, in this study, themes emerged from the transcripts of the interviews (both whole group and individual interviews) as well as notes from the observation from both the Lesson planning and the Lesson presentation and therefore, data was triangulated.

Moreover, Yin (2014) distinguishes between a single case study and a multiple case study. Since I chose this study to be a single case study, I did not dwell much on discussing a multiple case study. A single case study can be understood as a single *experiment* (Yin, 2014). In this study, the "experiment" was to explore how Grade 6 mathematics teachers engage with textbooks during Lesson planning and Lesson presentation. According to Yin (2014), there are five rationales for a case study to be considered as a single case study, namely, a *critical case; unusual case*; *common case*, *longitudinal case,* and *revelatory case*. However, he attests that none of the five rationales are mutually inclusive, and therefore, a single rationale can qualify a case study to be a single-case study. The rationales that framed this study to be a single-case study were a *critical case*, and the *revelatory case*.

A *critical case* concerns itself with the analogous relationship that must exist between the case study and the theoretical prepositions - the single case can be used to ascertain whether the theoretical circumstances under which the preposition is formed and is indeed true according to the current findings or whether extending explanation underpinning the preposition circumstances may be needed for the theoretical preposition to be true. In this study, MKT theory by Ball et al. (2008) was used to explore the effect that SMK and PCK may have in the way teachers engage with the textbook during Lesson planning and Lesson presentation.

Lastly, Yin (2014) attests that with a *revelatory case,* the researcher gains access to observe and analyse a phenomenon which could not be accessed before due to limiting social factors. Such a study may not have been conducted previously because LS has recently been introduced in SA and it has been implemented on a smaller scale. Conducting this study will not only reveal and expose the nuanced tacit and/or explicit teacher activities that may promote or hinder their professional development process in terms of how they engage with textbooks during Lesson planning and Lesson presentation, but it also contributed knowledge on how LS has been conceptualised in SA. Furthermore, there seems to be limited literature on teacher engagement with textbooks during lesson presentation and lesson observation stages of LS in the SA context, therefore this study will also contribute a great deal to the body of knowledge in this regard.

In addition, Yin (2014) asserts that the findings of a single case study cannot be generalised but may produce the same result if conducted with different participants of the same cohort under the same context. Therefore, the findings in this study were not generalised however, teachers implementing LS regardless of the grade, should be able to make sense of and identify with the findings of this study as they relate to them.

4.6 Time horizon

Sahay (2016) contends that cross-sectional research is undertaken to answer a question or solve the problem of which, a case study is one of the examples of strategies that can be used. According to Saunders et al. (2009), a cross-sectional study is time constrained in the sense that data is collected at a particular opportune time, hence a snapshot. The main factor that gravitated my study towards cross-sectional time horizon was that the time for the teaching of *numeric and geometric patterns* is stipulated in the curriculum policy; therefore, data collection had to take place during that time. My interaction with the participants was anticipated to be at least over thirteen days comprising the following: a day for the initial meeting (participants told about the study and signing of consent forms), a day to decide on topics to select on patterns informed by the previous diagnostic assessments and formulation of a schedule of the host school and the *demo* teacher, three days for collaborative Lesson planning, three days for Lesson presentation. It is important to note that Lesson presentation was done after all the three lessons were planned.

4.7 Research procedures

The district director, the circuit management, centre manager and the respective circuit managers of the participating schools were asked to fill in the consent forms after having been granted permission by the KZN department to conduct research at the respective schools. Etikan, Musa, and Alkassim (2016) attest that sampling in research is necessitated by the reality that the population may be almost finite. The study was then explained to the participants, after which teachers were requested to fill in the consent form; principals of lesson hosting schools to fill in the consent forms, parents to fill in the consent form for their children to participate in the study and learners completed the assent form. Lesson plan development and lesson presentation/observation sessions

were observed, and audio/video recorded to cover anything that could have been missed *in situ*.

During lesson preparation, I observed teachers' use of curriculum materials specifically the curriculum (CAPS) and the textbook. While observing, I engaged by asking clarity-seeking questions as the need arose. While taking *memoing* and *journaling*, I took snapshots of what would have been significant in my analysis. During the observation of lesson planning sessions, the aspects that were observed, included whether the activities used were: exactly as they were from the textbooks, adapted to suit learners' level of comprehension and how; or totally changed in terms of rephrasing and/ or the use of digital learning tools. Furthermore, issues of sharing best practices in terms of methodology were also explored during lesson planning observations.

Further, during lesson presentation, teachers were observed on how they engage with textbooks and in so doing, the whole lesson was video recorded including all the participants of the lesson and their interactions. Three out of the eight participating school hosted a lesson where one teacher presented while the other participants observed the lesson. Teachers as participants were interviewed as a group using what Lloyd (2017) referred to as "informal conversational interview" to clarify or expatiate on interesting observations or interactions that were noticeable while the process of lesson planning was underway. However, if necessary, unstructured interviews were still conducted after the observation of the lesson planning and the lesson presentation sessions. Jamshed (2014) contends that unstructured interviews resemble a "controlled conversation" between the interviewer and the interviewee because the conversation is always skewed towards the interest of the interviewer. The interviews were also audio / video recorded. Video/audio-recordings taken during Lesson planning and Lesson presentation observations were transcribed and analysed.

4.7.1 Research population and sample

Sampling is a technique that a researcher undertakes to systematically select a relatively smaller number of individuals from a pre-defined population to serve as participants of the study for the researcher to fulfil the objectives of the study (Sharma, 2017). Therefore, the population of this study was mathematics teachers of Grades 5 to 8 in the district who have been involved in LS since 2018 and therefore, form the sampling frame of this study. Taherdoost (2016) suggests two sampling techniques that need to be adhered to when

doing sampling informed by the research design of the study – probability (random) and non-probability sampling. According to Taherdoost (2016), the former technique is concerned about every member of the population having an equal chance of being sampled whereas, the latter, which I used in this study, refers to the researcher's intent to examine real-life phenomenon and solely relies on the researcher's judgement. Non-probability sampling is mostly associated with a qualitative case study research design (Taherdoost, 2016). Purposive sampling and convenience sampling (Taherdoost, 2016) are the forms of non-probability sampling that were used for this study.

In the education district where the study was conducted, there are four LS clusters implementing LS. For this study, a functional cluster comprising of Grade 6 teachers was selected from the four clusters as the participants of this study, hence purposive sampling. I defined a functional LS cluster as a cluster that had been able to host at least four LS cycles since they started implementing LS. Although choosing a functional cluster was the primary inclusion criterion to participate in the study, convenience was also considered where proximity was a secondary inclusion criterion. In other words, the location of schools where participants are based had to be in close proximity to where I reside for easy access, hence convenience sampling. The sample was then constituted by eight Grade 6 teachers within the population. The profile of teachers used as participants in my study is presented in Table 2. The information which culminated into the teachers' profile was collected through Annexure D.

Table 2: Profile of teachers selected as participants.

NAMES	GENDER	AGE CATEGORY	QUALIFICATION	EXPERIENCE as a mathematics teacher	PHASE TAUGHT	MATHEMATICS PD workshop attendance
T1	F	36 – 45 years	Diploma and certificate	6 – 10 years	Intermediate	Yes
T2	F	36 – 45 years	Bachelors' degree	6 – 10 years	Intermediate	Yes
T3	M	36 – 45 years	Diploma and certificate	6 – 10 years	Intermediate	Yes
T4	M	36 - 45 years	Bachelors' degree	6 – 10 years	Intermediate	Yes
T5	F	36 – 45 years	Diploma and certificate	16 years and above	Intermediate	Yes
T6	F	46 and above	Diploma and certificate	0 to 5 years	Intermediate and Senior	Yes
T7	F	36 – 45 years	Bachelors' degree	16 years and above	Intermediate and Senior	Yes
T8	M	28 – 35 years	Bachelors' degree	0 – 5 years	Intermediate	Yes

Any sampling technique has its strength and weaknesses. While the strength of purposive sampling is the fact that it is cost-effective, convenient, and ideal for exploratory research and it is not time-consuming, its weakness is that the findings cannot be generalised (Taherdoost, 2016). Therefore, in this study, it was not the intention to generalise the findings; however, to gain in-depth knowledge and understanding on how teachers engage with textbooks during planning and teaching. In addition, Etikan et al. (2016) contend that while convenience sampling is affordable; non-strategic nor purposeful, it is also subjected to the researcher's bias and the problem of outliers. Outliers are cases who happen to be in the data but do not belong to the data (Etikan et al., 2016). Problems of outliers were not experienced because the participants were already purposively selected.

Additionally, Yin (2014) presents the concept of screening the participants' cases before the actual commencement of collection of evidence, however, guiding against it being extensive as if it were the actual study or a "mini" case. He argues that the purpose of screening participants is to collect evidence that they qualify to serve as cases in the study and should be done prior to the actual collection of evidence for the study. A demographics form (see Annexure D) as evidence that participants are indeed Grade 6 mathematics teachers, and their qualifications (for the purpose of screening) was given to them to fill in before data was collected to ascertain their fitness to participate in the study.

4.7.2 Description of grade 6 Numeric and Geometric patterns

CAPS in grade 6 under both numeric and geometric patterns requires learners to determine equivalence of different descriptions of the same relationship or rule presented verbally, in a flow diagram, in a table and by a number sentence. Under geometric patterns, learners are expected to investigate and extend geometric patterns looking for relationships or rules of patterns represented in a physical or diagram form, sequences not limited to constant difference or ratio, of learners' own creation, and represented in a table. In addition, learners are also expected to demonstrate the general rule for the observed relationships and determine input values, output values and rules for the patterns and relationships using flow diagrams and tables. Lesson planning and lesson presentation in this study were informed by the aforementioned concepts. The mathematics knowledge that is needed by the teacher to be able to teach the

aforementioned concepts among others are: general knowledge of patterns in everyday life (CCK), describe, investigate and extend patterns from concrete to abstract levels (SCK), find the rule and be able to use the rule to represent a pattern in a flow diagram and table (SCK), the extent to which patterns were done in grade 5 and depth and breadth of patterns in grade 6 and beyond (HCK), integration of patterns with other topics within the mathematics discipline within the grade and beyond (HCK), integration of patterns with other subjects (HCK), common errors and misconceptions that learners normally make on patterns (KCT), anticipated learner responses (KCT), learners' different learning styles and context (KCS) and objectives of the lesson (KCC).

4.7.3 Description of the case

In this study, the sample comprised of eight Grade 6 mathematics teachers from different schools across two circuits belonging to one Circuit Management Centre (CMC). However, because circuits are neighbours, these schools form one LS cluster. All the teachers in the sample have taught Grade 6 mathematics for at least three consecutive years. Half of the group (comprising of six teachers and 210 learners) was introduced to LS in 2018 but did not complete a cycle, and the remaining half in 2019 (also comprising of six teachers and 187 learners). Therefore, as previously mentioned, in this study, eight Grade 6 mathematics teachers were used as participants and 397 learners were used as "indirect" participants since learners were not the focus of the study. The 2018 group completed their first cycle in 2019 and were yet to start with the second cycle (planned to start in April 2020) when they were prohibited by the coronavirus lockdown. The 2019 group had planned lessons for presentation in 2020 but were also unable to present due to the same reason mentioned above. For both 2018 and 2019 implementation, the selected schools' mathematics subject teachers and two SMT members (the Departmental Head and the Principal), attended a workshop on LS on two different days (one day for SMT members and one day for subject teachers). For subject teachers, the workshop was more practical with video demonstrations of what LS entails whereas for the SMT members, the additional element was management and support of LS at school level. Therefore, it is fair to say that LS implementation at the time of data collection in this cluster was at the initial stage.

In SA, as discussed in Chapter 2, the JLS cycle was adapted to include the diagnosis of the problem as the first step of the cycle. Consequently, in as much as this step of the LS

cycle is not the focus of this study, it deemed important (out of interest) to inform the reader how the topics for the lessons were planned, observed, and selected. Prior to selecting topics to be used, a diagnostic test was administered to all grades in February 2018 to identify topics that are challenging to learners (as the South African LS cycle prescribes). The test was set by the teachers informed by the previous year's/grade's work schedule. That is, Grade 6 learners wrote a Grade 5 paper etc. After marking, item and error analysis was done and then topics that learners poorly performed in were selected to be the ones that will be addressed through LS. A schedule of lesson planning sessions was drawn up. I visited all the lesson planning sessions for all the lesson presentation sessions that were hosted in 2018. The 2019 cluster was invited to observe the 2018 cluster's last two lessons that were carried over to 2019.

4.8 Data collection technique

Before I explain the data collection techniques I used in this study, I clarify the mathematics curriculum from where the topics that the focus of LS in this study were, are located. According to CAPS, the topics *Numeric patterns* and *Geometric patterns* in Grade 6 are set to be taught in Term 1 with the recommended teaching time of five days and in Term 2 with a recommended teaching time of three days (DBE, 2011). One lesson on Numeric patterns and two lessons on Geometric patterns were observed. Lesson plans were developed by one cluster comprising of eight Grade 6 teachers out of the six clusters that are implementing Lesson Study in the district. This cluster planned lessons using any or all the textbooks that they have in their possession as a resource. The selected topic in the textbooks was explored against the scope stipulated in CAPS.

In this study, I collected data through observations and interviews. I noted "areas" for elaboration and engaged the participants through whole group and individual interviews to explain their actions. In as much as I entered the research field as an observer, and not a participant, I drew on my subjective experiences to draw up an observation tool and ask impromptu questions during individual and whole group interviews since the interviews were unstructured. The details of each are presented in the next paragraphs.

4.8.1 Observation

Yin (2014) distinguishes between two types of observations namely, direct observation and participant observation as sources of evidence in case study research. Direct

observation involves the researcher observing what takes place in the real-world setting of the case without interference, involvement or influence on the participants' actions and utterances, whereas in participant-observation, the researcher may play the role of being a participant as well as the observer (Yin, 2014). This study adopted a direct observation because the researcher was immersed in the teachers' explicit or tacit social cultures, thoughts, understandings, and deliberations that shaped how they engaged with textbooks in the LS context during collaborative Lesson planning and Lesson presentation.

However, while observations enable the researcher to see the interaction *in situ,* it is difficult to cover every detail if there is only one observer (Yin, 2014). To mitigate this limitation, the lesson planning and lesson presentation were audio/video recorded while being observed so that every finer detail of interactions that could have been missed during the face-to-face encounter is captured. There was a short break between the lesson planning session and the interview session allowing the researcher to ensure that all the actions that needed to be covered in the interview to eliminate bias, were indeed captured for discussion during the interview.

Yin (2014) suggests that observation can be conducted casually or formally, this study adopted the latter. Two observation tools (Annexure B and Annexure C) were used to collect data during lesson planning and during lesson presentation, respectively. These annexures were developed informed by the elements of the MKT framework and Remillard (2005) and Brown's (2011) mode of teacher engagement with the textbook, which were used as a lens to examine data in this study as explained in the previous chapter to enable the researcher to respond to the questions. Discussion on what the observation tool was designed to observe is attended to later in the next subsection. After each observation session, a group interview was conducted for the researcher to better understand teachers' actions and interactions during Lesson planning and Lesson presentation.

Drawing on the research question of this study – How do mathematics textbooks contribute to teachers' conceptual understanding of *patterns*? only teacher engagement with the textbooks were the focus of the study and not the learners. However, during lesson presentation, appropriate photographs of learners' work, because of the interaction proposed by the teacher on the textbooks were taken. Yin (2014) asserts that

photographs during observations can help the researcher convey the phenomenon with ease.

4.8.2 Interviews

In addition to observations, I used whole group interview and individual interviews in this study. According to Yin (2014), interviews are crucial as the source of evidence in case studies because most case studies are pertaining to human affairs and/or their actions. Kajornboon (2005) defines interviews as “a systematic way of talking and listening to people” (p. 2), therefore data is collected from the participants through conversation.

Since this study is rooted in phenomenology through interpretivism, phenomenological interviews were used as the form of interview. According to Roulston and Choi (2018), in phenomenological interviews, the researcher takes a “neutral stance” while examining the participants’ lived experiences of the phenomenon and the meanings they make thereof and/or attach thereto.

Data was collected using unstructured interviews because interview questions were derived from the observation to clarify or corroborate the observed information and therefore, the interview questions could not be developed prior to the observation. Alshenqeeti (2014) contends that unstructured interviews are more flexible and *open-ended*, the researcher does not need to prepare questions prior to the interview and participants are asked different questions in no particular order. Yin (2014) distinguishes between different types of case study interviews namely, prolonged case study interview, shorter case study interviews and survey interviews in a case study. He attests that a prolonged case study interview is carried out over a longer period of time (approximately 2 hours) on different settings and the primary participants also serve as “informants” more than participants enabling the researcher to corroborate information with the secondary participants referred to by the primary participants. On the contrary, shorter case study interviews are carried out over a shorter period of time (approximately 1 hour) and are used to corroborate findings that would have already been established or understand the interviewees sense of reality (Yin, 2014). The latter form of an interview concerns itself with a survey of which this study is not a part. Informed by these assertions, this study adopted shorter case study interviews which were used to corroborate observations obtained from observing Lesson planning and Lesson presentation sessions to better understand the implicit and tacit interactions that teachers demonstrated. Since the type

of interviews that were conducted were unstructured and conversational, the interview questions could not be predetermined; therefore, the interview protocol could not be developed beforehand as is the case with structured interviews.

While according to Yin (2014), some of the strengths of case study interviews is that they are targeted and therefore focus directly on case study topic, he acknowledges that there may be bias due to poorly articulated questions, participants responses (wanting to say what they think the researcher wants to hear - reflexibility) and inaccuracies due to poor recall of events. In this study, the interview questions were clarified so that they could be understood easily by the participants.

Furthermore, Yin (2014) argues that interviews have a deficiency of not allowing the interviewees to think about their responses and/or better ways of articulating the response because they must respond to the questions asked instantaneously. In this study, participants were not pressured into responding. I was very patient and gave them enough time to think about their response regardless of whether they requested for more time to think or not.

4.9 Data analysis

Yin (2014) presents four strategies that are useful in analysing case study data, namely, working your data from the “ground up” relying on theoretical propositions, developing a case description, and examining plausible rival explanation. He also highlights that these strategies are not mutually exclusive and therefore, more than one strategy may be used simultaneously. In this study I analysed data using two strategies, that is, *relying on theoretical propositions* (used the theory that frames the study to organise and shape the data collection plan and to direct the analysis of the case study data while describing the contextual factors of the settings) and *working your data from the “ground up”* (data suggesting other concept(s) impacting on the findings of the study but however, related to the researchers’ experience and may not necessarily be covered by the theoretical proposition). For the former strategy, which was more inductive, the transcribed data was used as a source for emerging patterns resulting into themes and the formulated themes were then linked to the theoretical framework propositions that framed the study. Whereas, for the latter strategy, which was more deductive, the researchers preconceived and predetermined knowledge (of which some may be informed by literature), and

experience was used as a source for emerging patterns – subscribing to the notion of inductive - deductive qualitative study as discussed in 4.3 above.

Yin (2014) posits that computer-assisted tools such as Atlas.ti, can assist the researcher code and categorise data, especially since these tools cover both text and video-based data. Therefore, the software as a computer analytic tool that was used in this study was Atlas.ti which was used to analyse data sets obtained both from observations as well as from interviews. The manipulation of data on Atlas.ti included grouping information to relevant arrays; compilation of matrix of categories, placing evidence under each category; creating flowcharts for examining the data; tabulating the frequency of occurrences and arranging the information in chronological order.

All the data that was collected was surfed; valued; manipulated in search of patterns, insight or concepts that were most frequent and common and was all used in the analysis to respond to the research questions - inductive. In addition, my knowledge of teacher engagement with the textbooks was used in the interpretation of data during analysis - deductive. For a high-quality analysis, Yin (2014) presents four principles that need to be adhered to: *all collected evidence* should be attended to and linked to the research questions; *all plausible rival interpretations* should be addressed and supported by evidence; the *most significant aspects* of the study should be addressed in the analysis and the researcher should also make use of his/her own *prior knowledge* in the analysis of the case findings. In this study, these principles were incorporated in the way data was analysed using thematic analysis (TA). Scharp and Sanders (2019) contend that TA “is a qualitative method for identifying, analysing, and reporting patterns within a data corpus” (p. 117).

In this study, as I transcribed the data, I highlighted interesting features on the data informed by the research questions and the theoretical frameworks. For instance, as teachers shared different methodologies on how to answer the selected activity, they would exclaim with content upon learning something, or as they realised the mistake they may have made when they were doing the activity themselves. The learning features were then highlighted forming codes. Similar codes were combined to form themes which are presented in Chapter 5. Both inductive and deductive approach were used to form codes and in turn themes. For example, when teachers were not sure of the procedure and answers that they obtained from textbook-selected activities and found themselves

having to use the teacher's guide for assurance. However, complained that teacher's guides to not assist them much because they provide them with answers only. While these observations inductively conscientised me of the need to add flesh (educative features such as pedagogical features) to mathematics teacher guide for teachers to meaningfully benefit from them, they also deductively made me aware of the content gaps in both the SMK and the PCK dimensions. Consequently, upon merging the both the inductive and deductive analysis in the aforementioned example with the respective codes, *procedures of solving problems involving patterns* emerged as the theme.

After transcribing the data, I read them and familiarised myself with quotations that would assist me respond to the research question. I then inductively and deductively coded the data according to categories, codes and finally themes. In addition, themes were described, interpreted, and aligned to quotations that validated them. However, Braun, Clarke, Hayfield and Terry (2019) argue that there is a very thin line between codes and themes but what is important is that the codes (whether as words or phrases) validate the themes.

Braun et al. (2019) contend that TA has some pitfalls, namely, the researcher's ne may decrease the validity of the findings; the researcher's inability to make sense of the data collected and conceptualise it ; researcher's inability to link extracts to themes; *weak and unconvincing* analysis as a result of a high volume of themes overlapping albeit minimal overlapping of themes is permissible; failure to support themes with relevant and appropriate extracts and codes and finally, data interpretation not matching the study's theoretical framework. Subsequently, Braun et al. (2019) suggest ways that a researcher could follow to minimise the above-mentioned pitfalls namely, familiarising oneself with the collected data and identifying items of potential interest; generating initial codes; searching for themes; reviewing potential themes; defining and naming themes and finally producing a report. To mitigate these pitfalls, in this study I read through all the data items critically, actively, and analytically while noting the items of interest. I further coded each data item inclusively, comprehensively, and systematically from the beginning using Atlas.ti while bearing in mind that codes can be semantic or latent. I ended the coding phase by collating codes and data relevant to each code using matching colours. I then clustered similar codes to form a theme (using thematic map on and started thinking of the relationship between themes in terms of the research questions and literature, and the supporting evidence (coded extract) and disregarded those that seemed insignificant

for the study. Scharp and Sanders (2019) argue that a theme captures the "salient aspects of the data in a patterned way, regardless of whether that theme captures the majority experience" (p. 117). In line with this assertion, the number of codes that formed the theme were insignificant. I then refined the remaining themes and decided on the order in which I presented them when reporting as well as coded extracts to use to support them.

4.10 Quality criteria

Quality and integrity of a study is ensured by the evidence that its data collection instruments are valid and reliable (Mohajan, 2017). Over three decades ago Lincoln and Guba (1986) conceptualised the concept of trustworthiness to include criteria of credibility, confirmability, dependability, reflexibility and transferability (Guba, & Lincoln, 1994). These concepts and their application to this study are briefly discussed in the next paragraphs.

Credibility

Credibility concerns itself with the extent to which the researchers' representation of views in the study "fits" with the core-searchers (if applicable) and respondents (Connelly, 2016). In other words, Connelly (2016) posits that credibility is about the researchers' confidence in the "truth" of the findings. Connelly (2016) contends that this criterion is analogous to internal validity in quantitative research because it concerns itself with the truth of the study and its findings (Polit & Beck, 2014). In this study, data collection techniques were triangulated because data was collected through Lesson planning and Lesson presentation and observation after which interviews were conducted for collaboration. Issues of member checking were incorporated in this study for example, I asked questions to validate an observation or repeated statements or phrases to validate an understanding of a point/suggestion/proposal that teachers may have raised while immersed in collaborative lesson planning or during the unstructured interview session. In addition, data collection was video recorded authenticating all the processes that transpired as data was being collected. Teachers' consent forms and learners' assent forms as evidence of peer debriefing were also filed and stored. In addition, a follow – up interview was conducted to further ask questions that emerged after data was collected and, in this interview, video clips of Lesson planning and Lesson presentation and observation were shown to the participants. Therefore, the findings were presented with

confidence because they relate to what transpired in the natural setting during data collection.

Confirmability

The confirmability criterion concerns itself with the extent to which the findings of the study are informed by the participants' view of the phenomenon being studied and not the researcher's view (Connelly, 2016). Korstjens and Moser (2018) highlight that this criterion is concerned about the degree to which the findings of the study can be confirmed by other researchers for the same enquiry under the same settings. Therefore, an audit trail was established since all documents pertaining to the study were available. Issues of member checking were permitted to ensure confirmability since essential information for checking the accuracy and adequacy of the research was provided. Furthermore, data triangulation was used in this study to realise this criterion.

Dependability

Data would be seen to encompass the dependability criterion if the same results are obtained using a different sample but the same instrument under the same conditions and settings (Connelly, 2016). Polit and Berk (2014) contend that dependability associates itself with the way data is stable over time and through the duration of the study while Connelly (2016) argues that dependability is like reliability in quantitative research. In this study, all data collected was filed and chronologically labelled for easy access should there be a need to access it, for example, interview transcripts, thereby maintaining an audit trail. Furthermore, to ensure dependability in this study the following were considered, a detailed description of the research design and the plan to implement, and ground operations of how data was collected and analysed. By so doing, any researcher that conducts the same study would be able to fully understand how the study had been conducted.

Reflexibility

According to Connelly (2016), this criterion concerns itself about the researchers' self-reflection in terms of bias and relationships to the participants as well as the probability of how these relationships and researchers' views may affect the findings of the study. I jotted down notes in my notebook of what I had observed and a question to ask during interviews on lesson planning and lesson presentation. At the end of the day, I would go through the questions jotted and reflect on them ascertaining if the questions asked were

really conversational or were they in any way gearing teachers to respond in a particular way during interviews and thereby promoting bias. This reflection conscientised me more of good and bad phrasing of questions for the next sessions.

In this study, I have observed collaborative Lesson planning sessions before since the initial implementation was in 2018 and am therefore familiar with the participants and the interactions that take place *in situ*. The participants are also familiar with me around during these sessions that I seem to pose no threat anymore as the subject advisor. Furthermore, information gathered was presented in a descriptive manner and not a judgemental manner because the participants' insight, perception, and views of their engagement with textbooks was the core of the study and not that of the researcher's.

Transferability

Transferability refers to the degree to which the results of the qualitative study can be transferred to similar context or settings but with different participants (Nowel et al., 2017). This criterion concerns itself with the extent to which the inquiry can be generalised (Nowell et al., 2017). Even though Choy (2014) teaches us that single case study findings may not be confidently generalised, Yin (2014) attest that findings of a single case study may produce the same result even if the study is conducted with different participants of the same cohort under the same context. The issue of generalisations in qualitative research embeds itself on the degree of probability an event may happen under similar conditions and refers to this concept as *fuzzy generalisation* (Bassey, 2001). A *fuzzy generalisation* is a generalisation that is "neither likely to be true in every case, nor likely to be untrue in every case" (Bassey, 2001). It is an event that may happen and replaces the certainty of scientific generalisations in quantitative research (Bassey, 2001). In addition, Bassey (2001) attest that fuzzy generalisation serve as a powerful tool that can guide a professional action; however, he admits that there may be less credence on *fuzzy* generalisations if it is not supported by research which clearly describes the context of the generalisation as well as the evidence justifying it. Therefore, since the findings of this study cannot be generalised, I can make a *fuzzy generalisation* that the study could yield the same or similar findings if grade 6 mathematics teachers are used to investigate the same phenomenon in the context of Lesson Study because they (teachers) are exposed to similar background (discussed in Chapter 1). However, if the same study had to be conducted to teachers that have not been exposed to Lesson Study, there could be less

chances of findings being similar because teachers may not be comfortable to freely discuss and express their views without fear of being judged by their peers.

4.11 Ethical consideration

Ketefian (2015) posits that the existing ethical guideline in research focuses on human participants that are to be protected from physical, mental, and social harm while the researcher displays ethical codes *inter alia respect for persons*, *beneficence,* and *justice*. Furthermore, for this study to be conducted, permission was sought from the ethics committee of the University and was granted.

The following ethical practices were observed:

- Explain purpose: the purpose of the study was explained to all direct (teachers) and indirect (parents and learners) participants of the study during the distribution of the consent forms and is also explained in the consent form.
- Voluntary participation: participants were not coerced into taking part in the study. They were reminded of their right to withdraw any time without consequence if they deemed necessary to do so.
- Informed consent: Participants were required to give informed consent by signing the consent forms to be part of the study as participants. Parents signed consent forms permitting their children to participate in the study. Learners also signed assent forms. However, for those who did not grant permission, arrangement was made to reteach the same lesson after data were collected so that no learner misses out on any learning process.
- Confidentiality: data collected from this study remained confidential. What transpired during the research process remained between the researcher and the participants. Issues of confidentiality were consented in the consent forms teachers filled in before the commencement of the research.
- Anonymity: pseudonyms were used for the participants, schools, and different titles of textbooks. Participants were given a code for example, teacher 1 (T1), T2 and so on depending on the number of participants that were present in the initial session of lesson planning. Participating schools were given false names and the different types of textbooks used during lesson planning and lesson presentation were allocated letters of the alphabet, to conceal the identity of participants. Learners' faces were not shown during classroom observation since they were not the focus.

- Justice: all participants were given fair and equal treatment when they had to engage with the researcher. I did not have any favourites.
- Risk: There were no major risks anticipated since the Lesson Study process was NOT changed for the purpose of this study. However, the only risk for learners could be to lose out on teaching time if their parents may decide not to give consent and/or learners may choose not to grant assent. To mitigate this risk, arrangement was made to re-teach the lesson after data had been collected.

CHAPTER 5: PRESENTATION OF FINDINGS

5.1 Introduction

In this chapter I present the findings of the study stemming from the data collected through observations and unstructured interviews. Broadly, the presentation is guided by the research questions as well as the theoretical framework used for the study. The research questions (RQ) that guided this study were: (1) How do mathematics textbooks contribute to teachers' understanding of *patterns*? (2) How do teachers use mathematics textbook activities to inform instructional decision-making during collaborative lesson planning? (3) To what extent is teacher engagement with textbooks eliciting their awareness of coherence between the intended (CAPS) and implemented curriculum (textbooks)? and (4) How do teachers use textbooks during lesson presentation? However, more themes emerged from the first research question. Since this study is contextualised by two stages of the LS cycle, collaborative lesson planning and lesson presentation/observation, data obtained during collaborative lesson planning responded to RQ1, RQ2 and RQ3. Data obtained during lesson presentation responded to RQ4.

I observed three lessons on the teaching and learning of *patterns.* The lessons were planned and presented by the same Lesson Study team. One teacher but different every day, was selected by the team to lead the lesson planning session. In line with the case study design, my intention was to gain an in-depth understanding of how mathematics teachers engage with textbooks through Lesson Study. My in-depth understanding of this phenomenon has enabled me to formulate the themes according to which the findings are presented. This, therefore, justifies why the findings are not organised according to the number of lessons observed. In addition, since I conducted the interviews when it was necessary to clarify some of the observed manifestations, the findings under some of the themes in this chapter may not include interviews.

To substantiate the findings stemming from the interviews, I included the verbatim quotes from some of the participants' responses. Similarly, I used vignettes to illustrate the findings stemming from the observations of the lesson planning process and lesson presentation.

5.2 How mathematics textbooks contribute to teachers' understanding of patterns during lesson planning

As mentioned above, findings presented under the above-mentioned themes stem from the data obtained from the 2nd stage of the Lesson Study cycle – lesson planning. I define mathematical understanding of *patterns* as the ability to draw from related and appropriate concepts that may have been previously learnt and procedures (appropriate method to use in solving a problem) to solve a mathematical problem. But, since the research question is about teachers' mathematical understanding of *patterns*, I extend the definition of mathematical understanding to include not only the content aspects (Subject Matter Knowledge - SMK) but also the pedagogical aspects (Pedagogical Content Knowledge - PCK). From the analyses of data concerning the contribution of textbooks to the teachers' understanding of patterns, the following themes emerged: procedures of solving problems involving patterns, functional relationship, description of patterns, and equivalent representation of patterns.

While procedures of solving problems involving patterns refers to "new" methodologies or previously unclear methodology that became clear using different textbooks during lesson planning, functional relationships refer to the pairing of one input value (independent variable) to one output value (dependent variable). Description of patterns refers to the statements and interpretations that teachers made assisted by textbooks to describe patterns and therefore improve their understanding of patterns. By equivalent representation of patterns, I am referring to different representations of the same pattern. Teachers with the understanding of patterns would know why a mathematical idea (a mathematical thought that could assist in solving a problem) is important and how to relate it to relevant contexts. A mathematical idea can be communicated in a variety of ways; it can be communicated verbally, written, or visual to expound on a mathematical concept.

5.2.1 Procedures of solving problems involving patterns

During observation when teachers worked out answers to the textbook selected activities, they would sometimes argue if the response one is offering is correct and would then use the answers on the teacher guide to back them up. This was evident when one of the questions in the textbook selected activity was, "How do you know that the rule is correct?" and the conversation among teachers unfolded as follows:

T2*: I know it because I have eh…divided eh…the area…the output by the input and then I got …yes. How do I know … how do I know that I am correct with the rule?* T4*: You use the different operations altogether, yah;* T6*: You use the inverse … Do you all agree …;* T2*: No, it's in the book;* T8*: Oh ok.*

Teachers seemed convinced that the method was correct after T2 assured them that was the answer from the teacher guide. The South African mathematics teacher guides for all textbook series briefly entails the overview of the unit highlighting what learners are expected to do in the unit; the topics to be covered in the unit and responses ONLY to all activities that are in the learner book. Hence, teachers stated that if they cannot get the answer, they try to work backwards to arrive at the answer reflected in the teacher guide. Teachers demonstrated a high level of trust in the textbooks because they seemed to use teacher guides either to get the answer if they could not get it correct or to check if their responses to the problem selected from the textbook were correct.

Having seen teacher interaction with the teacher guide prompted me to ask them (teachers) about the value of teacher guides in their practice, T2 responded:

…*, if I do my calculations before I give the learners the activity that will assist me when I am marking their work and I will also compare my own answers with the textbook, with the teacher's guide and I will be hundred percent sure ukuthi* [that]*, ok I did this and here it is, so I am correct.* T4 also emphasised the importance of teacher guides by stating that: … *It's where we also get help uhm… with textbooks because when we cannot find… when we want to check the answers, our own answers, we use …uhm…the teacher's guide.*

However, on the contrary, they bemoaned that teacher guides are not really guiding them as they are meant to, instead, they are just providing them with answers. This was revealed during interviews when T4 stated: *It does not guide us as it is written as a teacher guide [participants laughing]. But it give us answers.* This means teacher guides do not fully assist teachers. There seems to be a gap in them [teacher guides] regarding pedagogical support.

However, teachers were able to use different textbook series as a resource since there is no mathematics prescribed textbook. When teachers were asked how they thought textbook(s) helped them in planning the lessons, T4 responded as follows: … *when we ordered books, I even involved the other books, I was able to order books that was fruitful*

for us in our lesson uhm… preparation. When asked what he meant by fruitful, he stated that he saw textbooks that had better activities and methodology than the ones he was predominantly using at his school. So, planning a lesson in the Lesson Study context and using different textbooks enabled teachers to scrutinise content and pedagogical issues in the textbooks.

There was an observable discrepancy between finding the general rule for the numeric patterns and the geometric patterns. Finding the general rule for numeric patterns seemed relatively easy for teachers but, finding the general rule for geometric patterns without first converting it to a number pattern seemed to pose some challenges. Teachers would be stuck and resort to skipping the activity or substituting it with an activity whose answers they could calculate and taking it upon themselves to do the challenging activity at home for homework, this was evident when T1 stated: *Ok, I am also thinking what if we … we change this problem and then we go home, we make it our homework then next week… next week we have a presentation, maybe after presentation we can talk about it and see if we have uhm… the answers…*

In addition, when teachers were confronted with a decreasing pattern that seemed unfamiliar to them, some teachers suggested that that pattern be skipped and not selected and some suggested that it be selected because they could easily see that the rule was $\times \frac{1}{2}$, or $\div 2$ (see Figure 4). This was evident when the teachers had the following discussion:

> T4: *Ya, it's decreasing that one. We don't have to take that will be difficult for learners*; T7*: No, [singayithatha nayo], we can take that decreasing one; T4: Decreasing?* T7*: Yah;* T4*: Oh! it's easy;* T1*: It's easy;* T4*: Yah;* T1*: Ok. Is it dividing by two? Yah.*

So, textbook activities that may be skipped for one reason or the other by an individual teacher as he/she individually plans the lesson get to be selected through collaborative lesson planning. The selected problem is presented in Figure 4.

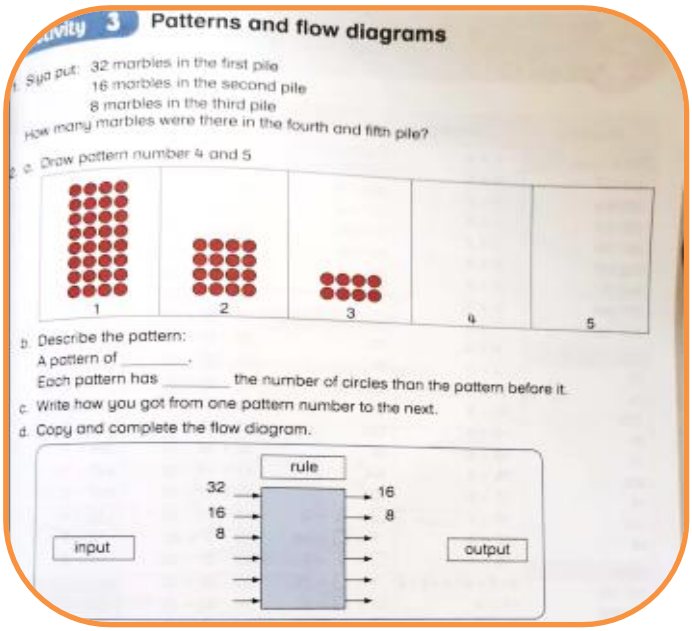


Figure 4: Source - Viva Mathematics Textbook, p. 85

So, the textbook activity exposed teachers to “challenging” activities that they had never encountered before. However, the attitude of not just skipping it if they could not get answers but rather engage on a productive struggle even after hours to get the answers was commendable. Therefore, in this instance, teachers learnt both the content and the pedagogy on geometric patterns and decreasing patterns. Also, interesting to note was that the response to the challenging question which was: extending a pattern of triangular numbers, was shared on the WhatsApp group by T1 the very same afternoon. She was able to understand how to get the rule for triangular numbers through U-tube videos. Teacher guides did not assist in this regard.

Upon observing the challenges that teachers had to teaching geometric patterns, I was interested in knowing how they normally teach geometric patterns, and therefore asked them (teachers). T1 responded: *What we do every day is done in patterns, but we usually teach learners as numbers that when you move from five, you go to ten, when you move from ten, you go to fifteen.* When teaching geometric patterns, teachers simply translated a geometric pattern to a number pattern and solved it. Therefore, through continuous practise activities on getting a general rule for a geometric pattern using the calculation plan, teachers learnt that a geometric pattern can be viewed and interpreted differently

by different people through calculation plans that they create and, as long as the calculation plan is correct, they would still arrive at the same number sentence (the general rule). However, although the focus of this study is not about comparing textbooks, the one glaring feature of one textbook series was the calculation plans to solve geometric patterns which were also described in the teacher guide. This confirms Remillard (2000) findings that teacher guides with content description assist teachers learn and improve their teaching. In addition, although some of the teachers had the textbook that emphasised calculation plans before, they had not given it the attention but were rather teaching geometric patterns as if they were numeric patterns. Important to note is, in as much as teachers are allowed to have as many textbooks as they would like to have as a resource, the reality is they tend to focus more on one than the other. Their focus is mainly on the textbook series that learners have. So, planning lessons collaboratively in the context of LS enabled teachers to compare different presentation of the same content and motivated them to order the one they felt had better features compared to the rest.

Upon lesson planning observation, it was evident that not only are teachers less challenged with getting an output value from an input value (forward process) and more challenged with getting an input value from the output value (reverse process), but they also forgot to teach the reverse process to learners. Forgetting to teach a certain concept automatically renders the teacher careless as the pit of learner content gaps directly expands.

Informed by what I regard as teachers' careless behaviour, I asked teachers what they think they learnt in the lesson planning session during interview:

> Ya*…I think we learnt a lot miss. So, mostly we always do the…the inputs and outputs forgetting …sometimes we do forget to … to reverse like from the outputs to the inputs. In most cases the learners are just given input and output.*

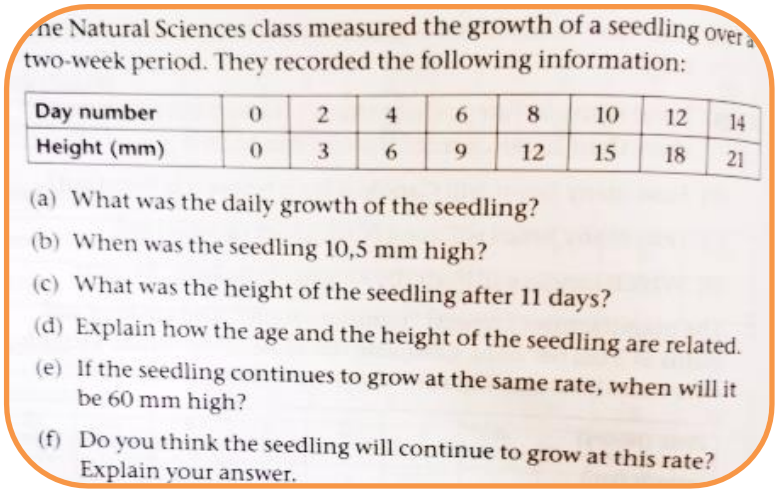
Through this activity, teachers learnt not only the importance of the reverse process in *patterns* but also the strategies that are needed to work out the reverse process since they said they normally forget to teach it.

Other teachers also stated that textbooks actually help them to learn the methodology that is to be used when teaching Grade 6 learners through the instructions that are set in the textbook for that particular activity. In this regard T6 stated: …*and the instruction in*

the book says the learners must be able to build house number four and house number five.

5.2.2 Functional relationship

In one lesson planning observation session, teachers were working out a problem where they had to explain how the age and the height of a plant were related. This was enabling them to apply their SCK as well as CCK to solve problems. The activity (refer to Figure 5) required the calculations process that would confirm the functional relationship between the age and the height of a plant. Some teachers contended that the question should be adapted or skipped because they saw it as challenging, but the final agreement was that they should carry on with it. Teachers indicated that there were two rules that would show the relationship between the two variables. Teachers could not relate one given variable to the input and the other to the output. For instance, this was evident when T1 stated: *I think it has two rules, don't you think?*



ne Natural Sciences class measured the growth of a seedling over a two-week period. They recorded the following information:

Day number	0	2	4	6	8	10	12	14
Height (mm)	0	3	6	9	12	15	18	21

(a) What was the daily growth of the seedling?

(b) When was the seedling 10,5 mm high?

(c) What was the height of the seedling after 11 days?

(d) Explain how the age and the height of the seedling are related.

(e) If the seedling continues to grow at the same rate, when will it be 60 mm high?

(f) Do you think the seedling will continue to grow at this rate? Explain your answer.

Figure 5: Source - DBE Textbook, p. 280

So, teachers were challenged by the context under which the activity was given and as a result, they learnt to solve patterns in context and assisted one another understand that there cannot be two rules in one problem. By this engagement, teachers directly figured out the functional relationship between the input and the output values and indirectly understood the concept of a rule in patterns.

As I observed teachers collaboratively planning the lesson, I noted that teachers would go to the board and work out the solution to the selected activity. One question of the

activity asked: If Mario had R5,50 and each doughnut costs 25c, how many doughnuts will she buy? Upon exploring different methods that they thought learners would use to work out the solution, T1 and T3 shared different methods (see Figure 6).

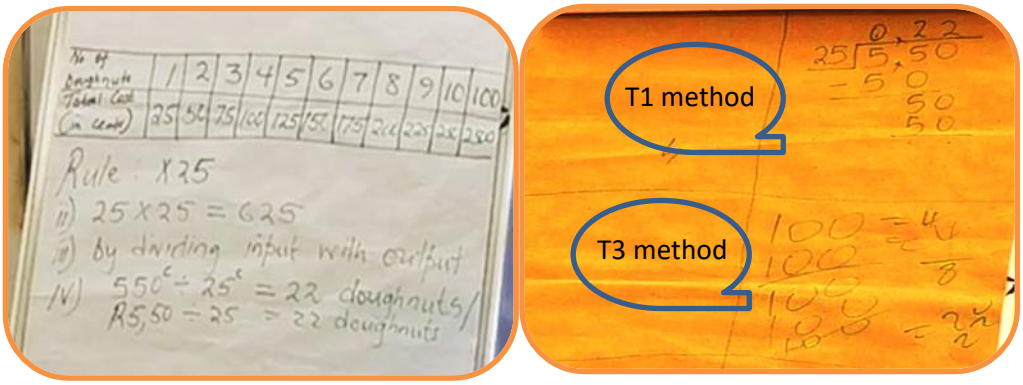


Figure 6: Teachers' solutions during lesson planning

It happened that T1 shared the working out that was incorrect, then T3 shared the correct process and solution to the problem but using a different method to the one used by T1. Realising her mistake, T1 stated: *Yes, I want to correct myself, ukuthi [that] what is it that I did wrong there. I said five rand fifty divided by twenty-five; if it's twenty-five like that, that is not in cents it's like twenty-five rands*. Through this activity, teachers learnt not only the functional relationships but also shared different methods and procedures. At the same time, teachers were exposed to knowledge integration (Horizon Content Knowledge - HCK) within the subject itself as they were working with patterns in the context of money.

5.2.3 Description of patterns

Description of patterns as mentioned above is also one of the themes that emerged through observation. Understanding a pattern involves ascertaining how a pattern extends from one position to the next. Therefore, as teachers were working out solutions to the selected problem during collaborative lesson planning, description of patterns was embedded in the working out. When teachers were responding to question (c) in Figure 5 which asked: What was the height of the seedling after 11 days? teachers worked it out by describing how the pattern extends from one position to the next. T7 described the pattern as follows: *Mhh! I was looking nje [just] at the table, [other participants laugh] I was halving the days and adding the days again.* T7's calculation is presented in Figure 7.

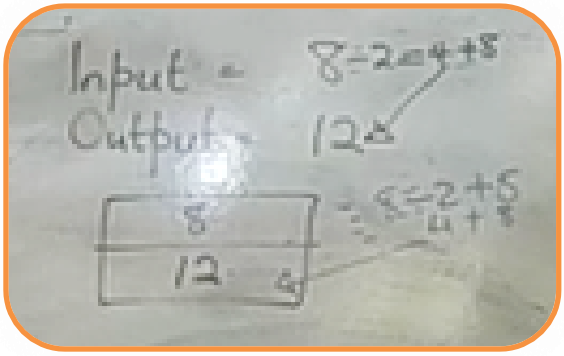


Figure 7: Teacher's calculation

T7's explanation was that to get the height of the seedling she divided the given day number by two and then added the answer to the same day number. In Figure 5 the given day number is 8, therefore, $8 \div 2 = 4$, and then $4 + 8 = 12$, which represents the height of the seedling on the 8th day. Through this activity, teachers got to understand the basic operations in mathematics and their inverses at a deeper level as they had to make deeper sense of the forward process to calculate the reverse process.

When I asked teachers to use the suggested method in Figure 7 above to calculate the input values to respond to number (e) of the same question, they seemed to struggle. In response to my request T6, who was leading the session on that day, despondently responded this way:

> *… using that half… halving thing. Yo! it's difficult … It's irreversible.* After a long discussion, teachers started doubting the method as T6 commented: *So now the question now is, is this method of halving and adding the half the right method if we can't reverse it;* T7*: … this method maybe it's only working for the output only we are trying to find from the output and input. That's where we get the problem … because it did happen when I tried to do the input and the output.*

However, as the struggle continued, T1 came up with the solution:

> *If I say sixty divided by three, I will have three twenties. Then ngikhipha lo [I take out] twenty omunye obe-add-iwe [the one that was added] owu [which is] half then I am left with u-forty [40];* T5*: Yes*

Since most of the selected problems from the textbook were contextual, issues of language analysis and terminology trying to understand the question to respond correctly

to the problem were prominent. One example is when a debate emerged in the lesson planning session when one teacher could not figure out how constant ratio is included in the activity that they had selected for lesson presentation where the topic was: Investigating and extending geometric patterns focussing on sequences involving constant ratio (Figure 8). T1 stated:

> *It's just that manje [now] I am confused now. Isn't the ratio what is … when you…the difference …? Uhm…No …no, T2 …T2 look at this one at this table. One number pattern is to six matchsticks* T2*: Yes T4: …that is a ratio.*

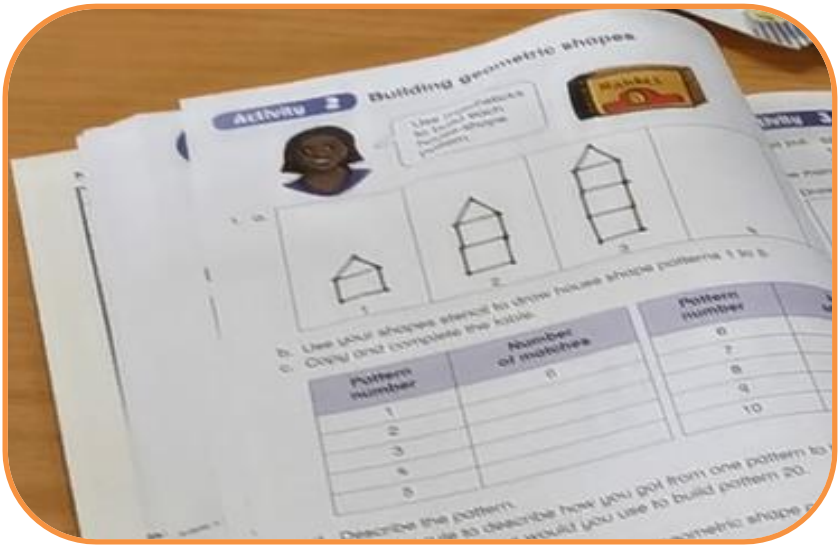
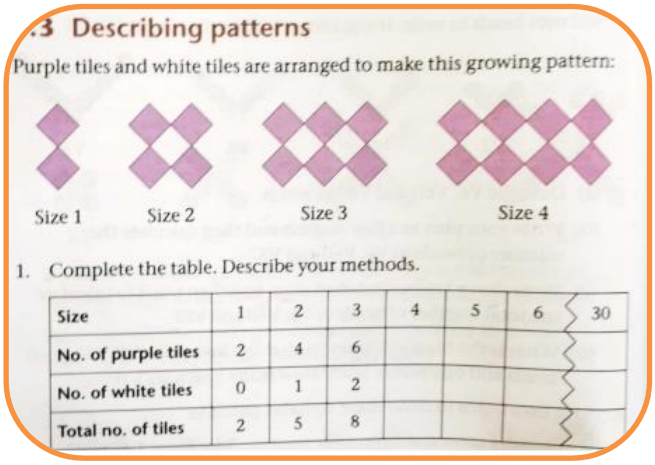


Figure 8: Source - Viva Mathematics, p. 84

There was again a discussion on generating a rule from the table. Some teachers could not understand how and why an input value is used to generate the general rule. Referring to Figure 9, T3 argued that the size number in the pattern has nothing to do with the number of tiles. When T1 asked T3 to respond to a question that asked how many white tiles would be in size 30, this is how the engagement unfolded T3*:*

Thirty uhm … thirty. They are five, four, six, there are five…there are five… lapha [here] they are five… in thirty they should be… ima [wait], four, five… They should be six I guess in thirty; T1*: In three [referring to Size 3] there are two, in thirty there are six?*



.3 Describing patterns

Purple tiles and white tiles are arranged to make this growing pattern:

Size 1 Size 2 Size 3 Size 4

1. Complete the table. Describe your methods.

Size	1	2	3	4	5	6	30
No. of purple tiles	2	4	6				
No. of white tiles	0	1	2				
Total no. of tiles	2	5	8				

Figure 9: Source - DBE Textbook, p. 156

Through this activity, teachers learnt that an input is an important feature that enables one to describe a pattern in a meaningful way, at the same time, features of functional relationships were embedded in the discussions.

5.2.4 Equivalent representation

Through observation, equivalent representation of increasing patterns seemed less challenging than those of decreasing patterns to such an extent that some teachers would prefer to not select the activity. During teacher discussions T4 stated: *Ya, it's decreasing that one. We don't have to take that will be difficult for learners* …Through textbook activities, teachers realised that equivalent representation in patterns can enhance learner understanding of pattern. I noticed this when T1 articulated what was required of learners in a selected activity as she said: *Learners need opportunities to see that changing the form of representation from geometric to verbal or to a flow diagram or to a table can sometimes help them to understand the pattern.* Textbooks assisted teachers learn not only how to represent a decreasing pattern in equivalent form but also how to teach it as it is. This finding is informed by T4s response when I asked them if textbooks assisted them understand patterns better: Yes … *and also assist me as an educator of how to approach…of how to teach geometric patterns and the tables. I think, taking the information from geometric patterns to the flow diagram, up until the table ….*

5.3 Teachers' use of mathematics textbook activities for instructional decision-making during collaborative lesson planning

I define mathematics classroom instruction as the interaction between the teacher and the learner around the lessons' mathematical activities that includes both the theoretical (collection of activities) and the operational (lesson presentation) part of the process of teaching and learning. Instructional decisions refer to the decisions that teachers make on how best to present the lesson for the benefit of all learners in their classrooms. Discussions under this section will respond to the second research question which seeks to investigate how teachers' use of mathematics textbook activities inform instructional decision-making during collaborative lesson planning. Data was informed by the second stage of LS – collaborative lesson planning. I have categorised the instructional decisions that teachers made during the lesson planning sessions into three themes which include (a) **lesson objectives** to be achieved, (b) the **methodology** that is to be used to present the lesson and (c) the **selection of activities** criteria.

5.3.1 Lesson objectives

Some of the common features of the lesson plan is the topic for the lesson and the objectives that should be achieved to ascertain the effectiveness of the lesson. In this study, the activities that teachers selected from the textbook and used in the lesson introduction until the conclusion were guided by the objectives that they wanted learners to achieve by the end of the lesson.

During observation of the collaborative lesson planning process, teachers constantly reminded one another about whether the selected activity will assist them achieve the lessons objectives. For example, this was evident in one of the lessons where they were dealing with equivalent representation of patterns. T2 contributed to the discussion in this way:

> *I was just suggesting what if we use this pattern here and do what we want our learners to achieve, maybe put aside for now in the introduction the questions that are here in the book, I don't know?*

T2 was in fact proposing that they should take only the geometric pattern from the textbook and ignore the questions relating to the pattern. But rather, formulate their own questions asking learners to represent the pattern in a flow diagram and in a table so that

the objectives of the lesson are achieved. Teachers were also very mindful of the lessons' objectives throughout their lesson planning process. This was evident when T1 said:

> *What if we take uhm… this one? The one that I was talking about in a policy document it's just that it has uhm… a constant difference. What are we, what uhm… the objectives? By the end of the lesson learners should be able …;* T7 completed T1's sentence and said: *… to determine the input and output … and find the rule*

5.3.2 Teaching and learning methodology

I refer to teaching and learning methodology as the method that teachers would use to teach in the classroom which will in turn enable learners to learn. Using the context of patterns, I regard teaching and learning methodology as the Input, Process and Output (IPO) process where teaching is the input, method used is the process and, the output as the evidence of learners' learning. Evidence of learners' learning may be formal or informal but in this study it was informal. In this study, teaching and learning methodology focusses on the textbook and the influence it may have on the teaching approach as teachers engage with textbooks during the lesson planning session.

The lessons that teachers collaboratively plan were designed to be presented in one hour. The one hour was split between the different steps of the lesson plan. The steps of the lesson enactment were allocated time as follows: introduction (10 min); presentation (25 min); consolidation (10 min) and classwork/homework (15 min). Therefore, once an activity was selected from the textbook, teachers were observed discussing how the content in the activity was going to be presented within the allocated time.

The teaching approach was directly informed by the selected activity. Teachers used teaching aids such as charts most of the time because they were selecting activities from different textbooks which their respective learners at their respective schools did not necessarily have. However, the activities in the learners' worksheet were directly transferred from the textbook.

Figure 10:Example of the teaching method adopted as it is from the textbook

The teaching methodology suggested in Figure 8 is exactly the method that was used to present the lesson reflected in Figure 10. The teacher-built houses using match sticks and learners had to extend the pattern as the textbook suggested.

Time allocated for each step of the lesson planning session was always a determinant of the interaction between the teacher and the learner. In Figure 8, learners were asked to use the matchsticks to build the houses from house number 1 to house number 5 and were given an example of the first three houses. Teachers agreed that in as much as they are taking the activity as it is, they will alter the presentation by coming to class with the first three houses built on the chart and learners would have to build house number 4 and 5. This alteration stemmed from the time allocated for the introduction. T3 commented: …*learners can be slow*. Teachers knowing their learners' pace, they felt learners will take over the 10 minutes allocated for the introduction to build the houses. Teachers had the following discussion:

> T1: *You can check which one will …uhm…save time for us*; T2: *The teacher to bring the chart with houses*; T4: *The chart saves time*; T1*: If bringing the chart will save time then we can do that*; T2: *With the houses …with the first three houses.*

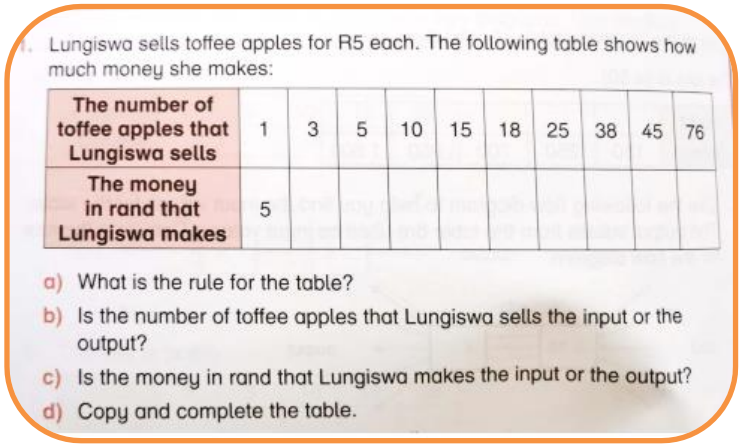
So, the alteration of the teaching method suggested in the textbook was implicitly influenced by the teachers' knowledge of their learners' pace of carrying out tasks and explicitly influenced by the time allocation per lesson plan step.

Solving selected activities from the textbook also sensitised teachers of the possible mistakes and misconceptions that learners make drawing from their experience. In an activity where some of the input values were skipped, teachers knew that learners would not notice that some input values have been skipped and provide the output values as if input values were chronological. For example, in Figure 5, the first question asked, "What was the daily growth of the seedling?" This was evident when some teachers commented:

T6: *What is it that we are agreeing on guys? It's one comma five or …or plus…plus 3, because what I am afraid of is that maybe the child will not notice that there are days which are not*; T5: … *ya [yes] there are days which are not recorded.*

This awareness enabled teachers to provide hints to questions to assist learners minimise mistakes. T1 suggested: *What if we give them and tell them that remember there are missing numbers*.

As teachers were planning the lesson, they showed awareness of the common misconceptions that learners have. Teachers were aware that given the problem illustrated in Figure 11, learners would represent money in cents and not convert it to rands (the currency used in South Africa). This was demonstrated in the following discussion: T1 *Yes, they will be able to know that it is one rand fifty. The problem will start when they have to write one rands fifty. Most of them…;* T7*: …will write it as hundred and fifty; T6: They will write it as one hundred and fifty.* To assist learners, teachers resorted to asking learners to express their answers in rands and in cents. This deviation altered the original textbook activity which had asked learners to express their answers in rand (s).



Lungiswa sells toffee apples for R5 each. The following table shows how much money she makes:

The number of toffee apples that Lungiswa sells	1	3	5	10	15	18	25	38	45	76
The money in rand that Lungiswa makes	5									

a) What is the rule for the table?
b) Is the number of toffee apples that Lungiswa sells the input or the output?
c) Is the money in rand that Lungiswa makes the input or the output?
d) Copy and complete the table.

Figure 11: Source - Solutions for all Mathematics Textbook, p. 74

Textbook activities enabled teachers to vary the skills that learners need to demonstrate when responding to questions. As a result, in as much as most of the selected patterns were increasing patterns, some were decreasing patterns. It also emerged in their discussion that teachers seemed not to be too familiar with decreasing patterns and felt that decreasing patterns were challenging for them. This was evident in the discussion that teachers had deciding on whether to select a decreasing pattern or not. The

discussion went as follows: T1 *So here we have a flow diagram. Oh! this one is, decreasing?* T4*: Yah, it's decreasing that one. We don't have to take that will be difficult* T7*: No, …, we can take that decreasing one;* T4*: Decreasing!* T7*: Yah;* T4*: Oh! it's easy;* T1*: It's easy;* T4*: Yah;* T1*: Ok. Is it dividing by two? Yah.* The selected decreasing pattern did not only expose learners to deceasing patterns calculation strategies but, it also exposed teachers to the methodology of teaching it.

Important to note was, teachers' thinking about their learners' thinking and ability prompted them to change, where appropriate, not only the content but also the context of the activity but within the framework of the textbook activity. While other teachers felt that textbook selected activities made them embody the learners they teach in terms of cognitive demand, other teachers felt that textbooks expose them to different types of questioning.

These teacher challenges because of selected textbook activities and teacher-learner embodiment prompted me to ask teachers how they think textbooks assisted them plan the lesson. This became apparent when T2 said: …*using the textbooks helps us in a way that some of the activities are an eye opener on what is going on …uhm…with the learners when they do activities because we even struggle to … to find some answers*. So, by implication, a problem that teachers found difficult to solve would have to be modified may it be in terms of content or teaching methodology so that the information is accessible to learners. On the other hand, T5 responded: *Yes Miss. It's more or less like T1 has said. I wanted to say it help us to get different methods of questioning.*

5.3.3 Selection of activities

This study's context - LS advocates for the use of purposeful activities in the process of teaching and learning. Therefore, selection of activities refers to the way in which textbook activities were selected, that is, whether activities were taken as they were from the textbook, textbook activities altered or activities were created by teachers during lesson planning session. this themes' focus is on whether teachers selected activities influenced their instructional decision-making.

Predominantly, all the activities used in the respective lessons were selected as they were from the textbook, however, in some cases the activities were altered and fragmented to achieve the objectives of the lesson. Therefore, the findings under the current theme

focus on the context under which activities were selected, i.e., as they were from the textbook (unaltered), altered activities and fragmented activities. Selected activities that tested the same skill and competences from learners as the textbook intended using the same context and numbers were regarded as unaltered. I refer to altered activities as those selected activities that tested varied learner skills and competences to those intended by the textbook. Fragmentation refers to splitting the questions' sub questions, for example, use some for introduction and some for presentation.

5.3.3. (a) Selection of activities without alteration

As mentioned in the previous paragraph, teachers were observed selecting and using activities as they were from the textbook. Teachers seemed to be very happy and content with textbook activities. This was evident during lesson planning when in one instance they found an activity that was a step towards the achievement of the objective of the lesson: T2*: … where they will complete either both the input and output, if you can just take it as it is…yah from the book.* In addition, as teachers were selecting activities, they would read and evaluate the activity even in terms of resources. For example, teachers knew that if they select a geometric pattern with two different colour tiles, the colours will not come out as per original copy once photocopied with a black and white photocopier - which they have at their respective schools. Instead, they would change the questions on the pattern from the textbook to suit the colours that would come out once a copy of the pattern has been made so that the activity makes sense to the learners.

In an activity where matchsticks were used to build a pattern, some teachers suggested that maybe the matchsticks should be substituted by just ordinary sticks because matchsticks must be bought. One teacher commented that sticks would require more work as they would have to be cut to same length while matchsticks are already the same length. This was evident when T3 requested: *Can we just stick to this example exactly as it is? Matchsticks, they are ok and maybe on another activity then we can use the sticks for something else, because here we are taking this one and they are using matchsticks*.

Although T1 expressed the view that sometimes textbooks have errors, the views of most of the teachers were that textbook activities were best to use because textbooks had been screened by the DBE, therefore are approved to be curriculum compliant, and address all cognitive levels. Upon interviews, I asked teachers why they felt it was important to take activities as they were from the textbook, T4 responded: *to accommodate all learners*

we must take all the table … I think this work has been checked … has been checked and assessed so we cannot edit the work that is in the textbook. We must take all of it …

5.3.3. (b) Alteration of selected activities

During collaborative lesson planning, I observed that the level of difficulty of the activities as perceived by teachers for their learners, learners' context and background and time allocated per lesson plan step were predominantly the reason for altering activities. Teachers felt that when the lesson is being introduced, the activity used for introduction should be relatively easy to accommodate all learners. As a result, an activity would be selected but numbers changed (reduced) for an introduction. This was evident when (T1) suggested: *What if we take this activity and then reduce … reduce eh… the numbers.* Referring to Figure 11, the context of the question was toffee apples, but teachers decided to change the context of toffee apples to sweets because they felt that their learners do

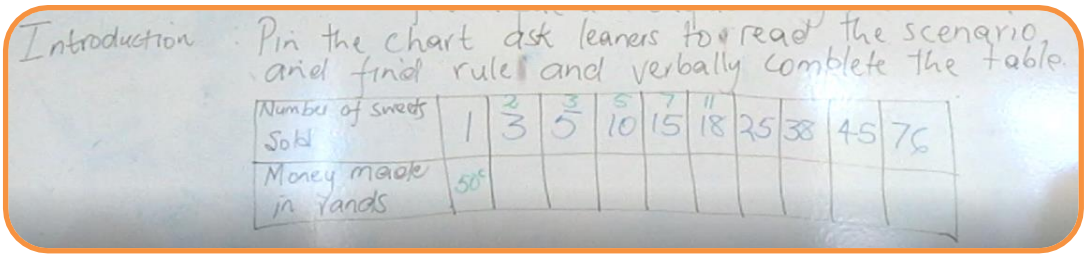


Figure 12: An example of an altered question

not really relate to toffee apples and using sweets instead would enable them to practically demonstrate the activity. Numbers written in black in Figure 12 above were numbers from the textbook and numbers written in green were the adapted numbers. This was evident when T6 commented: *Why can't we use this one as it is? [pointing at the toffee apple scenario];* T5*: But I like that one [referring the adapted version of the activity] because it is … it makes the introduction interesting because they are active rather than putting a chart … it is more learner centred.*

When teachers were planning a lesson on equivalent representation of patterns, they still took the activity as it was from the textbook but changed it by adding a question on another representation that was not initially there. For me to understand the teachers' reason for taking activities as they were from the textbook as observed, I asked if they were taking the activity as it was from the textbook and T1 replied: *We are taking it as it is, but we will add there and there, because they didn't talk about the … about the flow*

diagram and the table angithi [isn't]? In another lesson, I asked the same question T1 responded: *Eh …on the book it's not one, two, three. It's one they skipped two then they wrote three.*

When I asked teachers how textbooks have assisted them plan the lesson, teachers' views were that textbooks assist them by giving them direction and "a clue" and, without textbook activities, their self-developed activities would be substandard. This was evident when T5 said: *I can say focusing on the questions that we developed ourselves can discourage the level of thinking of the children because if we look at the books, the questions …there are those challenging questions which may encourage the child to think more…even more.* Responding to the same question, T2 said: *I wanted to say uhm… textbooks has helped us a lot because activities, some of the activities were taken from the textbook as they are, and those activities helped us to create our own …*

5.3.3. (c) Fragmented activities

I also observed teachers fragmenting an activity based on the purpose of the lesson, time allocation, and the step of lesson plan during collaborative lesson planning. In some instances, part of the activity would be used for an introduction while the remaining part gets used for the presentation due to time allocation. However, in terms of activity selection, activities were still selected as they were from the textbook. With reference to Figure 8, this was evident when T1 pointed out: *In an introduction, they use matchsticks. Then in a presentation they use the same activity, but they draw. As it is said in (b) that they must draw shape…shape patterns one to five. It will depend on the time that we have for presentation, but I agree with you let us draw in the presentation. Let us use the same activity.* So, in this lesson, number (a) was used as an introduction and number (b) and the rest of the sub questions were used for lesson presentation in as much as the activity was taken as it is from the book.

5.4 Mathematics teacher's awareness of coherence between the intended and the implemented curriculum.

This section aims to respond to the third research question (RQ3) which seeks to ascertain teachers' awareness of the coherence between the intended and the implemented curriculum. In other words, as teachers engage with textbooks, do they appreciate that textbook content should mirror the prescripts of the curriculum. I identified

two themes that shed light on the findings relating to RQ3, and they include verification of subtopics and selection of subtopics for instructional purposes. Verification of subtopics refers to the scenario where a subtopic/concept dealt with in the textbook is verified from the curriculum to ascertain its appropriateness. Selection of subtopics refers to the teacher's broader knowledge that informs the criteria used to select the subtopics as well as the breadth and depth of the content within the subtopic in the specific grade as prescribed in the curriculum. Therefore, the forthcoming findings are presented according to the themes: verification and selection of subtopics. Since unstructured interviews were used to gain in depth understanding of the phenomenon, if necessary, not all themes reflect interview findings.

My observation was that teacher's level of *kyozai-kenkyu* was higher at the initial stages of the collaborative lesson planning process compared to the latter stages because they interacted with more than one curriculum resource at the initial stages extensively but, at the latter stages they interacted with mainly the textbook. By the initial stages of the collaborative lesson planning process, I refer not only to the stages where teachers select subtopics under *patterns* and attach objectives of the lesson to the selected subtopic, but also to the stage where teachers determined the prior knowledge that learners need to have to be able to tackle the cognitive demands of the current lesson. Regarding the latter stages I refer to selecting activities for the introduction, presentation, and conclusion of the lesson. In the initial stages of lesson planning process, teachers selected subtopics using mostly the Curriculum, Assessment and Policy Statement (CAPS) and the Annual Teaching Plan (ATP). Textbook (s), thereafter used to select activities based on the selected subtopic. In the latter stages of lesson planning, teachers used mostly textbooks. The ATP is the scheme of work that is informed by policy. I consider the CAPS and the ATP as the intended curriculum and the textbook activities as the implemented curriculum drawn from the potentially implemented curriculum – the textbooks.

5.4.1 Verification of subtopics

Although teachers were interacting with the CAPS, ATP, and the textbook, they seemed not familiar with the contents of the CAPS in terms of both the scope of work that needs to be covered, i.e., the breadth and the depth of the content. Teachers did not know how to navigate the CAPS to get the information that they needed and would page through the CAPS page by page to no avail until they resort to textbooks. For example,

ascertaining whether patterns are taught in Grade 5, teachers rather paged through the Grade 5 textbook for what they believed would be a convincing response. When teachers were planning a lesson on *investigating and extending geometric patterns represented in physical and diagram form focusing on constant ratio,* they seemed not sure if geometric patterns are taught for the first time in Grade 6. In one lesson when teachers wanted to determine learners' prior knowledge on the abovementioned topic, they used Grade 5 ATP and textbook to see what learners had learnt in Grade 5 on geometric patterns. They could not find any geometric patterns on both the ATP and the textbook they were using. They concluded that geometric patterns are not taught in Grade 5, instead they are introduced for the first time in Grade 6. This was evident when T7 said:

> *…according to … to me, I have a grade five ATP right in front of me, there are no geometric patterns. It says… uhm… investigate and extend patterns. So, I think maybe they are doing it for the first time maybe in grade six looking at the ATP. I was trying to look at the document, and I was just listening to the question. So, this ATP for grade five, even the book, the grade five book we were trying to look for geometric patterns there is nothing.*

After I asked teachers to verify their conclusion that geometric patterns are not taught in Grade 5, they referred to the CAPS again and found that there are geometric patterns in Grade 5. As a result, they continued to page through the same textbook they had paged through before and found that in the next pages of the same textbook, there are geometric patterns. This was evident when T4 said:

> *So, our problem is that we, we opened on page two hundred and sixty-five where patterns start with numeric patterns and that is where we made our mistake. On page two hundred and sixty-five. Then if you look … uhm…on the next page we did not find any geometric pattern, but we are shocked that we do have ama-geometric pattern on page one hundred and eight.*

In one lesson when teachers were asked if they were going to use all operations in planning a lesson on *determining input values, output values and rules of patterns and relationship using tables,* they could not readily answer but rather referred to the textbooks and the CAPS to check which operations could be used. Again, the way teachers perused through the CAPS showed less knowledge of where in the CAPS the

response could be obtained, they just searched page-by-page. This was evident when T7 said:

> *Ok, page sixteen on the CAPS document. On the CAPS document but it's, talking about the input and output values for grade five and they have used tables. So now, we are trying to look in the textbook so we can give you the right answer that, all the operation signs are there … included in the tables. On the textbook, we've got the … what is this one [looking for the name of the textbook] …grade six, textbook [X] page hundred and fifty-three there are tables we are just trying to find if all the operation signs are there … yah.*

Eventually, based on their experience, teachers arrived at the conclusion that because they teach Grade 5 as well and they normally use all operations in as much as they could not arrive at that conclusion by using the curriculum, they had with them. This finding was very interesting because when they had to determine whether geometric patterns are taught in Grade 5, no teacher used his/her experience to confidently respond to the question.

5.4.2 Selection of subtopics for instructional purposes

After teachers knew they needed to focus on *patterns* informed by the ATP, they listed all the subtopics as illustrated in Figure 13 informed by the ATP. Thereafter, they selected subtopics that would address what they found needed to be addressed as per the diagnostic analysis, the first stage of the South African Lesson Study (SALS) cycle, within the broader topic of patterns.

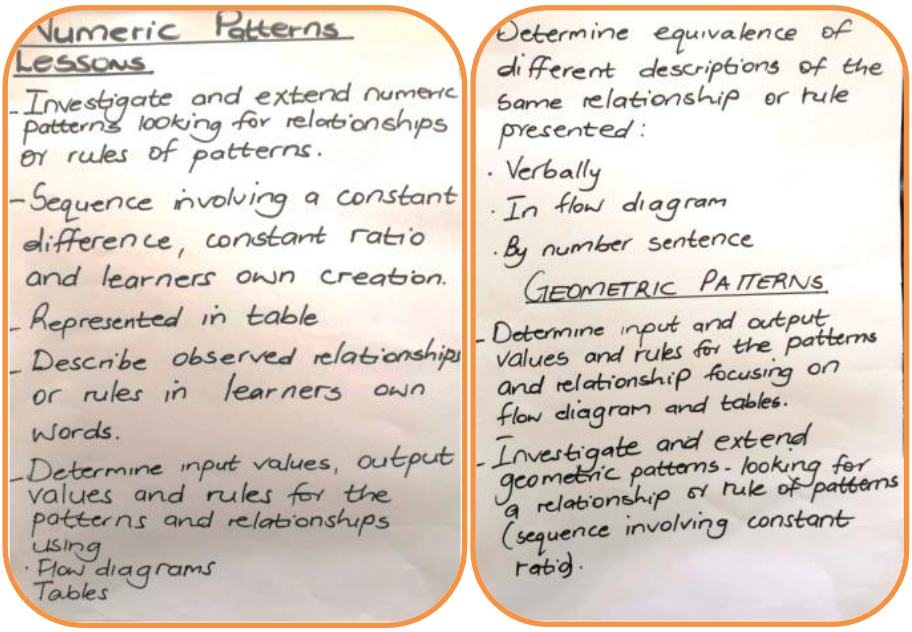


Figure 13: List of subtopics

For the reader to clearly understand the observed findings under this theme, I felt it was important to provide a brief layout of the *patterns* on the ATP. Patterns in the ATP are allocated 15 hours split into 9 hours for numeric patterns and 6 hours for geometric patterns. Teachers mainly focussed on the time allocation reflected on the ATP more than the one reflected on the CAPS because due to the outbreak of covid-19, the ATP was revised. The revised ATP contained only the fundamental topics. As a result, topics on the revised ATP were not sequenced the same way as in the policy. Therefore, subtopics from which lesson plans were developed were directly taken as they were from the ATP and packaged according to the time allocation. One of the subtopics was: *Determine input values, output values and rules for the pattern and relationship using tables*. Teachers' selected subtopics on patterns was informed by poor learner performance on the common test that had been administered to the Grade 6 cohort of 2018 in the selected LS pilot schools. The test was set, moderated, marked and analysed by Grade 6 teachers of the piloting schools. The selected subtopic's objectives would then be achieved by selecting activities from the textbook (s).

Observing teachers interacting with the Grade 5 textbook to verify certain aspect prompted me to find out if their reference to the previous grade textbook has the effect as the next grade textbook especially considering that primary school teachers sometimes teach one subject in more than one grade within the school. Therefore, upon interviews

when teachers were asked if they were aware of whether patterns are taught in Grade 7 and to what extent, they seemed not sure. This was apparent when T8 responded: *No, I am not aware …* and T5 responded: *I can say yes only because I have once teach…taught…teach grade 7.* Only one teacher said she knew just because she taught Grade 7. The other teachers suggested that if only the Grade 7 curriculum could also be included in the Intermediate phase CAPS document as per school structure primary schools going up to Grade 7, so that teachers could figure out what is expected of learners in the next grade. This was evident when T8 continued to suggest that i*t was…it would have been easier if it was included in the…this intermediate one.* Therefore, a teacher teaching Grade 6 may not be familiar with the curriculum content for Grade 7 because it is not contained in the Intermediate Phase policy. However, on the contrary, when teachers were determining the learners' pre-knowledge to one of the selected subtopics, they paged through a Grade 5 textbook and concluded that patterns were not taught in Grade 5. This conclusion stemmed from them not noticing patterns in the Grade 5 textbook. But the same teachers have the mathematics policy document for Intermediate Phase. This then led me to conclude that teachers do not actually read the policy document. They rely solely on the ATP and the textbook(s) for the grade they teach.

5.5 The teachers use of mathematics textbooks during lesson presentation

The findings discussed under this heading respond to the fourth research question: How do teachers use textbooks during lesson presentation? As stipulated in the introduction of this chapter. The findings also emerge from the third stage of Lesson Study – lesson presentation/observation. Through analysis of my observation of the lesson presentation and the unstructured interviews I conducted on how teachers use mathematics textbooks in the classroom, it was revealed that teachers use textbooks for **lesson enactment** and **assessment for learning**. Therefore, lesson enactment and assessment for learning are the two themes that characterise the findings relating to RQ4. While lesson enactment refers to the act of putting the theoretically planned lesson into practice, assessment for learning refers to the verbal and written informal assessments that the teacher executes to foster learning.

5.5.1 Lesson enactment

Although in the introduction and the lesson development stage teachers taught using charts with activities that they had selected from the textbook during lesson planning, in the conclusion of the lesson teachers used learners' copies of the textbook to give learners homework/classwork over and above the textbook selected activity that was in the form of a worksheet. Teachers gave learners work in the textbook to occupy and engage them since some learners would finish the classwork/homework worksheet while others were still busy. Towards the end of the lesson, T2 said:

> *… those of you who are already finished, and I have also given them some activity, some extra activities to do if you are finish. You are going to refer…* to *page one hundred and eighty-five… activity one and I have given you number one (a) for those who are already finished… your class work then you can just do this activity in your exercise book.*

Of interest to note was that the textbook activity selected by the hosting teacher during lesson presentation was taken as it is from the textbook compared to the ones selected from the textbook during lesson planning which were occasionally varied to match the level of comprehension of learners as well as the teaching approach.

When teachers were confronted with a decreasing pattern that seemed unfamiliar to them, some teachers suggested that that pattern be skipped and not selected and some suggested that it be selected as they could see that the rule was $\times \frac{1}{2}$, or $\div$ 2. This was evident when teachers discussed as follows:

> T4: *Ya, it's decreasing that one. We don't have to take that will be difficult for learners*; *T7: No, [singayithatha nayo], we can take that decreasing one; T4: Decreasing???; T7: Yah; T4: Oh! it's easy; T1: It's easy; T4: Yah; T1: Ok. Is it dividing by two? Yah.*

So, textbook activities that may be skipped for one reason or the other by an individual teacher as he/she individually plans the lesson gets to be selected through collaborative lesson planning.

Observed during presentation of one of the lessons was that the teacher (T4) believed so much in the textbook selected activity that he did not use his SCK to alter the input and output values on the chart during lesson presentation for the pattern to be mathematically

correct, as the one illustrated in Figure 14 is incorrect or, maybe even refer to the textbook for verification. Instead, he tried to swap the input and output values and allowed learners to represent the information on an incorrect flow diagram into a table. His uncertainty with the correct answer was evident when he responded to a learner who said the rule was ÷ by 1 as follows:

> *We divide by one, not exactly, not exactly. What actually that we…we are dividing by one, if we say divided by one, thirty-two divided by one is, is thirty-two ok, then sixteen divided by one is not two. Ok let's move together, let us move on we are going back to this question after we have done this, because we are still thinking.*

It is evident that the problem stemmed from the incorrect transcription of the activity from the textbook to the chart.

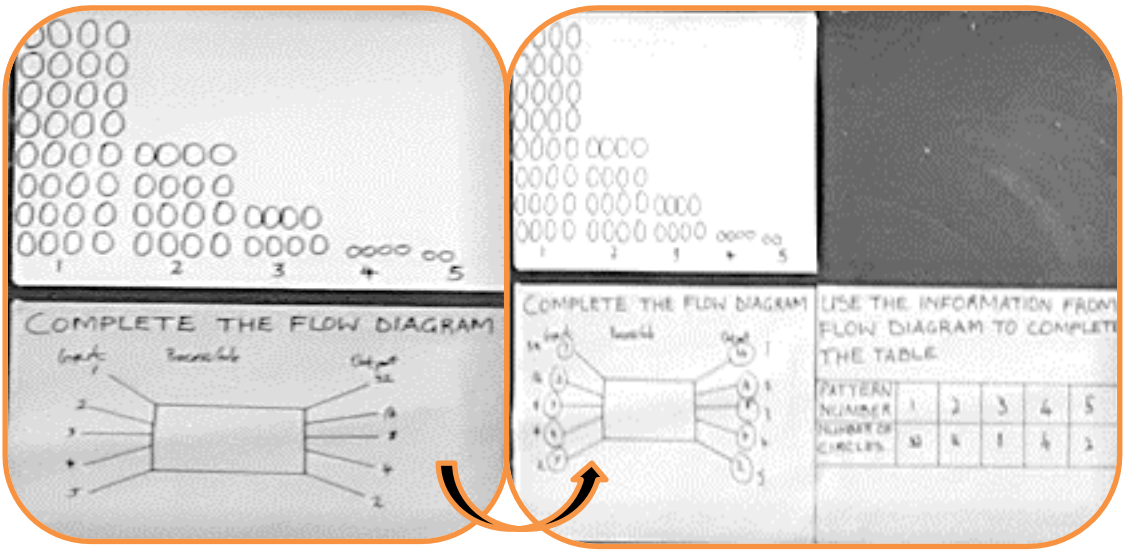


Figure 14: Different representation of patterns

The lesson ended without learners knowing what exactly the correct answer to the decreasing pattern was. So, this reveals that in as much as presenting textbook selected activities on the chart is accommodating because during lesson planning teachers use different textbooks that their learners may not have, information may be lost in the transcription.

During interviews, teachers were asked if the presented activities during lesson presentation were selected from the textbook, and they said yes, however, they shared a concern that they were confused during lesson presentation because the equivalence of the posed problem (see Figure 14) could not be correctly represented. They then referred

to the original textbook activity during interviews and it emerged that the activity had been copied wrongly from the textbook to the chart. Some information from the textbook was mistakenly left out. This was evident as T1 said: *on the book it is written thirty-two-sixteen. They gave a few to follow taken from there and come up with the rule that it's divided by two.* The diagrammatic representation was not directly translating to a flow diagram but rather showing different representation of a decreasing pattern.

Upon confusion, the teacher ended up telling learners that the rule is ÷ 2. When asked how he arrived at the rule, T4 responded:

> *I said let us move on then we'll go back, but I catch up later that I mustn't leave blank sum, the rule. Because that one maybe it will confuse learners as I am confused, I was confused. But I understood by looking at this one this divided by two. The answer is divided by two, but I was confused how it's divided by two.*

He further stated: *… and even us ourselves especially me I am not used in such flow diagram where it goes like this one exactly.*

5.5.2 Assessment for learning

Activities selected from the textbook(s) during lesson planning were used exactly as they were presented on a chart during lesson presentation/observation. For example, in one lesson when learners were asked to extend a pattern by drawing the number of marbles on stage 4, they all could figure out that there will be 20 marbles in stage 4 since there are 5, 10, 15 marbles from stage 1 to stage 3 respectively. Learner 1 and learner 2 drew it as illustrated in Figure 15.

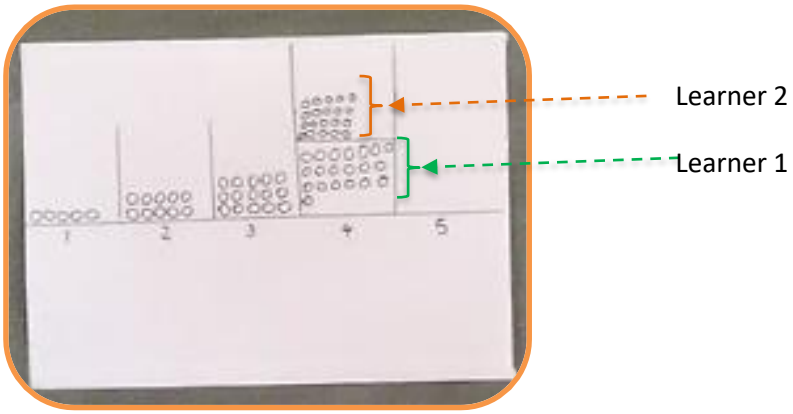


Figure 15: Example of learner's responses

Even though both learner 1 and learner 2 could count correctly, the presentation of marbles was different. The teacher did not ask learner 1 if the pattern is still the same as the previous stages or try to make the learner understand or figure out why her drawing was less acceptable compared to learner 2's drawing of marbles. Instead, he just asked if there was anyone who would like to correct learner 1's drawing. So, during lesson presentation, not all learners may have understood the concept. This was because the observers (i.e., LS team that planned the lesson) stood up and assisted learners that needed help as they walked around checking and marking their (learners') work while observing. They did not answer the problems for them but, they also asked probing questions (individually) that would assist the learner arrive at the correct answer. Although, this role of observers is not in line with the role of observers as it is practised in SA i.e., assisting learners, it provided me with some insight on what learners were grappling with. In another lesson, this is how an incorrect learner response was ignored T2*: What is the answer?* Learner*: Two thousand five hundred* T2*: She is saying two thousand five hundred. Two thousand five hundred. I can see some of the hands are still up. Here comes another two another one. Yes Mandla!* Upon observation it was noted that, there are learners who frequently would give a correct response after others had given an incorrect response but were not made to realise their mistake.

During interviews after observing the incorrect transcription from the textbook to the chart and how the teacher handled it, I asked the teachers what they think went wrong in the lesson, T1 responded:

> *Ok, I think uhm… the problem that we still have, I think maybe all of us, we don't want to focus to those learners who gives us uhm… the wrong answers. We rush to the learners who are giving us the correct …the correct ones.*

Consequently, teachers further acknowledged that they also need to understand the thinking behind the incorrect answers so that maximum unselective learning takes place.

CHAPTER 6: DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

In this chapter, I discuss the findings that were presented in Chapter 5. This study sought to explore Grade 6 mathematics teachers' engagement with textbooks in the context of Lesson Study. The purpose of the study was two-pronged: firstly, to explore mathematics teachers' engagement with the Grade 6 curriculum materials specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the Lesson Study cycle; and secondly, to establish teachers' awareness of the coherence between the intended and the implemented curriculum. To advance this purpose, I was guided by the primary research question: How do Grade 6 mathematics teachers engage with textbooks during the Lesson Study session? However, in an attempt to answer the primary research question, I was further guided by four secondary research questions. The secondary research questions enabled me to gain insights into how mathematics teachers engage with textbooks as they collaboratively plan and present lessons in the context of Lesson Study. The secondary research questions include: (a) How do mathematics textbooks contribute to teachers' understanding of *patterns*? (b) How do teachers' use of mathematics textbook activities inform instructional decision-making during collaborative lesson planning? (c) To what extent is teacher engagement with textbooks eliciting their awareness of coherence between the intended (CAPS) and implemented curriculum (textbooks)? and (d) How do teachers use textbooks during lesson presentation?

This chapter is organised according to four main sections (excluding the Introduction): the discussions of the findings per the four research questions; reflection on the affordances of the theoretical framework; limitations; recommendations; and conclusions. In the discussions section I have also responded to or answered each research question. By reflecting on the affordances of the theoretical framework for this study, I demonstrated how the MKT framework as well as the modes of teacher-textbook engagement proposed by Remillard (2005), and Brown (2011) guided me in the entire study to the point of responding to or answering the research questions. Given the implications of the findings for textbooks conceptualisation, I propose the framework that could be used by policy

makers to guide the conceptualisation and writing of mathematics textbooks. In the limitations sections I presented the factors or characteristics that impacted the findings.

6.2 Discussion of findings

In this section, I discuss the findings per RQ. In my discussion under each RQ, the first paragraph explains what the RQ sought to explore and briefly summarises the findings. The next paragraphs discuss findings in order of the research questions.

6.2.1 The contributions of mathematics textbooks to teachers' understanding of patterns

As stated in 6.1, the first research question explored the contribution of mathematics textbooks to teachers' understanding of patterns. Data used to respond to this research question was obtained from observations and interviews of the second stage of the LS cycle, i.e., collaborative lesson planning. Collaborative lesson planning within the Lesson Study cycle in this study enabled teachers to acquire some knowledge and skills through *kyozai-kenyu* that they would not be exposed to if they were working alone. Findings revealed that teachers' understanding of patterns is twofold i.e., the content and pedagogy which may be learnt or re-learnt as they (teachers) engage with the textbooks.

The study revealed that as teachers collaborated when planning the lesson, they shared different teaching methods and procedures, worked out solutions to the problem selected from the textbook which Lee and Tan (2019) refer to as *multimodal representation and juxtaposition of students' work*. Although teachers predominantly took the activities as they are from the textbooks, they collaboratively made a conscious effort to understand the activities before including them in their lesson plan and using them during teaching. In the process of discussing each activity on geometric and numeric patterns during collaborative lesson planning, teachers learnt new ideas such as calculation strategies from the worked examples in textbooks; functional relationships; describing patterns, and equivalent representation of patterns. However, from one of the textbooks, all the teachers learnt how to create a calculation plan to describe a geometric pattern. This confirms the assertion by researchers such Lewis and Perry (2014), and Takahashi and McDougal (2016) that Lesson Study creates an environment where teachers acquire professional learning. The other four textbook series used described a geometric pattern by first converting it to a numeric pattern. In addition, some textbooks series were

frequently used compared to others. Steenbrugge et al. (2013) contend that the textbook series that is less popular to teachers are textbooks with no detailed description of the content, didactical suggestions, theoretical and mathematical background knowledge. I argue that the omission of some calculation strategies in some textbooks emanates from not having a subject specific framework for textbook writing. Lesson Study afforded teachers an opportunity to deal with the challenging topic for learners to understand. As a result, teachers themselves ended up learning both new strategies and pedagogy as Mellor et al. (2018) espoused that textbooks have an influence on mathematics learning. Teachers' understanding of patterns would have been consolidated if their engagement with textbooks gravitated towards highest level of engagement, i.e., adapting the activities. Adapting the activities draws from and enhances teachers' content knowledge and their pedagogical skills – the two knowledge domains espoused by Ball et al. (2008). Therefore, if textbooks serve as the central resource of teaching and learning as this study depicts, more attention needs to be paid to the writing and screening of the textbooks for uniformity.

Therefore, my overall response to RQ1 is that, through LS, mathematics teachers who participated in this study gained not only knowledge and skills on numeric and geometric patterns but also learnt different methods and procedures to solve a problem as they engaged with textbooks. So, Lesson Study served as a model for teacher professional learning through collaborative lesson planning (Groves, Doig, Vale & Wadjaja, 2016). As teachers worked out solutions to different textbook selected activities, they learnt new calculation strategies and new approaches to teaching patterns thereby improving their SCK and KCT respectively. However, Neumann et al. (2014) contend that potential teacher learning is enhanced by textbooks that are accompanied by teachers guides that considers learners' ideas for example, possible learner errors/misconceptions on the topic. Therefore, since teacher guides seemed not to be too much of assistance to teachers in terms of pedagogy since they only provided them with answers to textbook activities, I argue that teacher learning would have been maximised by pedagogically driven teacher guides.

6.2.2 Teachers' use of mathematics textbook activities to inform instructional decision-making

This RQ concerned itself with the instructional decision-making that teachers' make because of their engagement with the textbook during collaborative lesson planning. I view instructional decision-making in the context of this study as the process whereby teachers select the content/activity and determine the pedagogy that will enhance meaningful learning to learners. Ball et al. (2008) contends that the KCT subdomain concerns itself with teachers' knowledge of the content and the didactic of teaching mathematics and proficient teachers in KCT need to demonstrate a balance between the two. Therefore, the teacher, the learner and the environment are the significant attributes to teachers' instructional decision making. These attributes shape the kind of interaction they (teachers) have with the textbook. Findings of this study revealed that teacher-text relationship is with fidelity. However, teachers occasionally adapted the tasks even though their adaptation was superficial.

Predominantly, teachers selected activities from the textbook with fidelity. That is, they frequently took activities exactly as they were from the textbook. While Remillard (2005) argues that for teachers to be able to design activities independent of the textbook, they need to be mathematically fluent. Stein et al. (2007) argues that teachers with significant content gaps tend to be *textbook bound.* The *following* mode concerns themselves with how well a textbook is written to guide the teacher (Remillard, 2005). Findings of this study confirmed what both Remillard, and Stein et al. attested to especially when teachers dealt with geometric patterns. Teachers taught geometric patterns as if they were numeric patterns as presented in some of the textbooks. Even though this study is not comparing textbooks, four out of five textbook series used during lesson planning, had examples showing exactly the same methodology of teaching geometric patterns, that is, converting a geometric pattern to a number pattern. Only one out of five textbook series dealt with geometric patterns by doing a calculation plan which enables a learner to view and interpret the patterns his or her own way. My view, therefore, is that although teachers mainly used textbooks with fidelity, the interpretation and presentation of geometric patterns in the textbooks did not mirror the prescripts of the curriculum. Given their blind loyalty to textbooks, teachers made instructional decisions based on what is in the textbook, i.e., they merely adopted converting geometric pattern into numeric pattern which is contrary to the curriculum prescripts. The mathematics curriculum for Grade 6

clearly states that learners should “Investigate and extend geometric patterns looking for relationships or rules of patterns.” (DBE, 2011, p. 19). A mere conversion of geometric patterns into numeric patterns flouts the essential investigative skill engrained in this topic where learners are required to look for relationship or rules. One can, therefore, trace the problem to the inaccurate curriculum interpretation in the textbooks. Valverde et al. (2002) contend that textbooks do not only mediate the intended and the implemented curriculum but, they are also an artefact that creates opportunities to learn by incorporating suggestive enactment instruction. Even though textbook activities are still subject to teacher interpretation, textbook suggested pedagogies are often adopted by teachers. Evidently, without the framework to guide the writing of textbooks, learners get presented with unequal learning opportunities, conceptual understanding, and most likely life opportunities.

The effectiveness of a lesson is normally determined by the extent to which the lesson objectives are achieved. While the crafting of lesson objectives is an aspect that features in lesson plan templates, Sekao and Engelbrecht (2019) contend that crafting of lesson objectives to match what is stipulated in the policy is an important feature of the South African Lesson Study (SALS) cycle. In line with Sekao’s assertion, during lesson planning, textbooks assisted teachers select purposeful activities to achieve the set objectives. During collaborative lesson planning, teachers would have professional conversations where they would debate which activity to select and which not to select, how to teach the selected concept, until they agree. Their agreement on the selected approach to teach the concept would be guided by the approach that the textbook used. Even though teachers predominantly selected textbook activities with fidelity, the resources and teaching aids were adopted and sometimes adapted informed by the selected textbook activity. For example, in one activity, the textbook was using toffee apples as a resource but, because teachers had adapted numbers in terms of cost price of the toffee apple by reducing them, they felt the need to change from toffee apples to sweets to be realistic and meaningful. Over and above that, teachers said their learners are more familiar with sweets than they are with toffee apples. Therefore, this suggests that in as much as teachers may have adapted the resources used in the textbook activity because of context, the textbook methodology remained unchanged regardless of whether the activity was adopted or adapted. So, the textbook activities framed the infrequent superficial adaptation of activities and the methodology that the teachers used to present

the lesson. Therefore, Lesson Study created a platform for teachers to be relevantly, meaningfully, and impactfully developed professionally by themselves compared to the traditional expert-led and top-down workshops that mathematics subject advisors conduct for teachers. Also, LS afforded them an opportunity for their discussions to be collegial as compared to congenial.

Although there were pockets of best practice where teachers occasionally adopted and adapted some of the activities that they selected from the textbook, this practice was done superficially. Teachers' adaptation of activities was mainly changing the number range and, in all instances, reducing it from what it was from the textbook on the basis that the original activity would be too difficult for learners. Context would also be occasionally adapted accordingly to suit the adapted number range and the chosen methodology. As the level of difficulty of the adapted activities was reduced, cognitive demand of those activities was also reduced – a phenomenon referred to by Leshota (2020) as critical omission to describe teachers' omission of content that detracts opportunity to mediate the lesson. This surely impacts negatively on the learners' opportunities to learn if compared to a learner who would be taught using the original number range from the textbook. Although I am cautious not to generalise, these findings could somehow explain the low level of performance in mathematics by South Africa's Grade 6 learners when compared to their counterparts in the region (SAQMEC, 2007). I argue that if teachers' engagement with textbook activities is superficial, the quality of activities in the textbooks become lowered by implication. This necessitates the educative nature of both the textbook and the teacher guide so that teachers get proper guidance in terms of pedagogy and proper explanation of concepts.

Teachers also felt that the textbook-selected activities assisted them cater for the different levels of difficulty of the question. Textbooks afforded teachers an opportunity to cater for the different learners' learning pace especially slow learners. In their (teachers) discussions as they selected activities, they would speak less of accommodating highflyers in the lesson and more of accommodating slow learners. This, teachers became more aware of as they worked out answers to textbook selected activity. Collaborative lesson planning in the context of LS afforded teachers an opportunity to think of the classroom environment and their learners' cognitive abilities and consequently adapt activities to suit their learners' needs. However, on the flip side, this adaptation

could lead to *distractive injection* (Leshota & Adler, 2018) as the cognitive demand of the activity would be compromised due to catering of slow learners.

As teachers were selecting activities from the textbook, they were also very conscious of the duration of the lesson to be presented. Time allocation for lesson presentation (an hour) impacted both the pacing and the teaching methodology. Teachers would even fragment an activity driven not only by the level of difficulty of the selected activity but also by time allocation per stage of the lesson plan. For example, part of an activity which is less cognitively demanding, would be allocated for the introduction of the lesson because the introduction is allocated only 10 minutes and the rest of the activity would then be covered in the presentation.

Working out solutions to the selected problems sensitised teachers to the misconceptions and errors that learners often make. In one lesson, teachers were concerned that learners would be confused with expressing their answers in rands and in cents (the South African currency). In addition, teacher engagement with the textbook in LS context enabled them to view different skills to impart to learners that are often not given attention, for example, decreasing pattern.

Teachers voiced out that in as much as they may have teacher guides, they (the teacher guides) do not really guide their teaching but rather provide them with the expected answers. This finding confirms what Leshota, and Adler (2018) revealed that, teachers resort to using the learner books because they include mathematics explanations, tasks, and exercises, instead of being assisted by the teachers' guides. The nature of these teacher guides, therefore, does not portray educative attribute of the teacher guide espoused by Drake et al. (2014), instead seems to cultivate a *shallow teaching syndrome* espoused by Vincent and Stacey (2008). According to Drake et al. textbooks as educative curriculum material should assist the teacher develop the mathematical knowledge bases to effectively enact the curriculum. This means the teacher guide is not educative enough to assist the teacher develop the mathematical knowledge espoused by Bell et al. (2008). This could consequently impede the implementation of the mathematics curriculum resulting in substandard learner output who may not be competitive in the global world. I assert that while the CAPS is very rich in its content, its intention may be compromised if there is no framework to guide the writing of mathematics textbooks. Although expected

answers assist teachers to ensure that their calculation may be correct if it yields the same answer reflected in the teacher's guide, they (teachers' guides) lack the pedagogical aspect that teachers also need the most. Mizoguchi and Shinno (2019) contend that the main activity teachers do when they engage with and study the curriculum materials (*kyozai-kenkyu*) is use their mathematical knowledge to plan lessons using textbooks. Mathematical knowledge involves both the SMK and the PCK (Ball et al., 2008). If the teachers' guide does not contain the requisite knowledge and skills to support teachers during collaborative lesson planning then, *kyozai-kenyu* is likely not to yield the intended purpose of teacher learning.

Teachers' resilience was implicit in teacher engagement with the textbook as they planned the lessons. Some teachers would suggest that an activity be deselected due its complex feature(s) they think would be challenging for their learners or unfamiliar skill that the activity demands while some would argue that an activity be selected. However, teachers would end up agreeing that the activity be selected. In this instance, LS afforded teachers an opportunity to learn as they dealt with unfamiliar skills and activities. Therefore, textbooks should be able to supplement teachers' knowledge deficit in a remarkable way especially since many teachers in the Intermediate Phase (Grades 4 to 6) did not specialise in mathematics. However, teachers learnt a lot through textbook-selected activities because, they worked out solutions to activities that they would have skipped if they were planning alone.

In response to RQ2: *How do teachers' use of mathematics textbook activities inform instructional decision-making during collaborative lesson planning*, my view is that LS provided the following affordances during the lesson planning stage: textbooks afforded teachers with a number of activities to select from regardless of whether the activities were adopted or adapted, in order to achieve the set objective; textbooks assisted teachers with pedagogy and the resources they are to use when presenting a lesson and, textbooks exposed them to the correct mathematical language to use when giving instructions to learners. Since teachers' interaction with the textbook was mostly with fidelity, the suggested teaching methodology embedded in the textbook selected activity was Implicitly adopted because even when digits and context was varied, the teaching methodology suggested in the textbook did not vary.

6.2.3 Eliciting awareness of coherence between the intended and implemented curriculum

The third RQ reads thus: To what extent does teacher engagement with textbooks elicit their awareness of coherence between the intended (CAPS) and implemented curriculum (textbooks)? Textbooks, as partially implemented curriculum (Valverde et al., 2002), are trusted by teachers in this study as they undoubtedly believe that they reflect what is in the policy. In addition, teachers seemed more familiar with the textbook than with the policy (CAPS), however, the Annual Teaching Plans (ATPs) which are transcribed from policy, guided their teaching in terms of content/topic sequence and pacing.

Teachers blatantly believed that textbooks were aligned to CAPS. For them (teachers), what was in the textbook was unquestionable. In determining learners' prior knowledge, teachers used mainly the previous grade textbook(s) and rarely the CAPS. When teachers tried to use the CAPS to check for learners' prior knowledge, they were not sure where to find the information in the CAPS. As a result, they relied on Grade 5 textbooks. However, teachers referred to the CAPS for verification when the need arose. The ATP is used more often than the CAPS because it outlines the sequenced topics, concepts, and skills to be taught and learnt and, the timeframe but, that is predominantly the only purpose, they use it for. However, regarding teachers' guides, teachers mentioned that the answers that are provided in the teachers' guide are sometimes incorrect. So, teachers believed that there was coherence between the CAPS and the textbook, and the incoherence sometimes existed between the textbook and the teacher guide.

Overall, in as much as teachers seemed to lack knowledge on how to navigate the CAPS but rather used the ATP, they were aware of the coherence between the policy (intended curriculum) and the implemented curriculum as they engaged with textbooks. Ball et al. (2008) refers to Knowledge of Content and the Curriculum (KCC) as teachers' knowledge of how topics (concepts) are interrelated within the mathematics discipline beyond the current grade level and, how topics can be integrated to other disciplines outside the mathematics discipline. Therefore, informed by these assertions, I argue that in as much as teachers were aware of the coherence between the intended and the implemented curriculum especially using the ATP, their awareness was superficial. I base this argument on the fact that teachers seemed not to be aware of the relevant interrelation

of *patterns* within and beyond Grade 6 but rather better understanding of the integration between *patterns* and other subjects as they engaged with textbooks.

6.2.4 Teachers' use of textbooks during lesson presentation

Teachers plan lessons so that their teaching promotes inclusive maximum learning to learners. This research question explored teachers' use of mathematics textbooks as they present the lessons. Findings revealed that activities presented to learners in the classroom were all selected from the textbooks.

However, the selection during lesson planning and lesson presentation varied. Even though most activities were selected with fidelity during lesson planning, some were superficially adapted but, during lesson presentation, all textbook activities were selected with fidelity. Activities that were selected during lesson planning were transcribed and presented on charts because learners did not have all the textbooks that were used by teachers. However, as teachers were transcribing from the textbook to the chart, some of the transcripts were incorrect because of engaging with their textbooks with fidelity. Activities selected during lesson presentation were selected by the presenting teacher using the learners' copy of the textbook. The presenting teacher would refer learners to the textbook activity after finishing the work that was planned for the day.

Overall, the textbook-selected activities were used by teachers to introduce the lesson, present the lesson, conclude the lesson, and give learners classwork/homework during collaborative lesson planning. Activities selected from the textbook during collaborative lesson planning were mediated and directed for the benefit of the learner (Lepik, 2015). However, the homework enrichment activity (for faster learners) during lesson presentation was individually selected by the respective teacher using the relevant learners' copy of the textbook should learner quickly finish activities that were collaboratively planned. This finding was in line with Danışman (2019) who contended that the textbook is mainly used by teachers in the classroom to give learners homework. As a result, enrichment activities were therefore not mediated during lesson presentation. This is contrary to the pedagogical aspects of KCS and KCT which prioritise students/learners and teaching (Ball et al., 2008). These findings imply that homework enrichment activities from the respective learners' copy of the textbook should be discussed during collaborative lesson planning as well.

6.3 Reflecting on the affordances of the theoretical framework to the study

Lesson Study does not only concern itself with teacher's professional development but, it also informs the system at large of the developments that need to be effected to strengthen the link between the intended and the implemented curriculum (Watanabe, 2019). Therefore, even though textbooks and teacher guides assist teachers understand *patterns* in mathematics, there are gaps that need to be addressed for teacher learning to be maximised for the benefit of the learner. I argue that indeed, while Lesson Study created a platform for teachers to learn, it also enabled me, the researcher, to realise the gaps that create a weak bond between the intended and the implemented curriculum, inter alia, lack of pedagogical aspects on the teacher guide and ununiform calculation strategies. I further argue that these gaps exist because of the unavailability of a subject specific framework that needs to be considered when writing textbooks and thereby suggesting ways to narrow it. By the framework, I do not refer to the finer details of the content that needs to be covered but I refer to the broader aspects that need to be considered when writing books. Examples of broader aspects could be the pedagogical issues such as: possible misconceptions that learners may have on the activity or topic, suggested teaching methodology, uniform calculation strategies, reference to policy and any other aspects that would make the textbook educative for teachers while at the same time, linking the intended curriculum to the implemented curriculum.

The Mathematics Knowledge for Teaching framework by Ball et al. (2008) enabled me to respond to my research questions and thereby deeply understand the phenomenon of Grade 6 mathematics teacher engagement with the textbook. The main domains of the framework are the subject matter knowledge (SMK) and the pedagogical content knowledge (PCK) with their respective sub domains. SMK includes *specialised content knowledge* (SCK), *horizon content knowledge* (HCK) and *common content knowledge* (CCK). Using the framework in terms of SMK, enabled me to understand teachers' misconceptions for example, generating the rule without including both the input and the output values (SCK); subtopics that they often ignore due to content knowledge deficit within *patterns* for example, decreasing patterns (SCK); teachers trust in the textbook for grading questions according to cognitive levels (SCK); lack of knowledge of connection between patterns and any other topic within or outside the grade (HCK). One other domain of the Ball et al.'s MKT framework is the *pedagogical content knowledge* (PCK) with its subdomains namely, *knowledge of the content and student (*KCS), *knowledge of*

the content and teaching (KCT) and *knowledge of the content and the curriculum* (KCC). In terms of PCK, the framework enabled me to realise the insufficient or lack of pedagogical notes from the textbook(s) to assist teachers understand the concepts better (KCT); how textbook activities are adapted to suit learners' level of comprehension (KCS); knowledge of an appropriate teaching aid to use to address the concept (KCT); use learners' misconceptions to guide their teaching (KCS and KCT); how the textbook(s) assist teachers with teaching methodology (KCT); the fleshless nature of the teachers' guide when it comes to pedagogy (KCT); teachers' overreliance on textbook(s) and neglecting policy text (KCC).

Remillard (2005) and Brown's (2011) mode of teacher-text engagement enabled me to respond to the primary RQ: How do Grade 6 mathematics teachers engage with textbooks during the Lesson Study session? Findings revealed that teachers engage with the textbook with fidelity informed by the *offloading* mode (Remillard, 2005) and similarly *following* mode (Brown, 2011). Comparing these modes to the rest of the modes of teacher-text engagement with the textbook that these scholars suggest, they are at the lowest level of the continuum.

The link between the intended curriculum and the implemented curriculum is the textbook (Valverde et al., 2002). Positive change in mathematics teaching relies on textbooks (Gravemeijer, 2014). However, the findings of this study revealed that the teacher guides (the component of the textbook that is supposed to guide the teacher) do not fully assist teachers because (a) they provide only the answers to the textbook activities, and (b) they lack the pedagogical aspects to teaching. I perceive the latter as the most important aspect that the teacher guide ought to have. Considering that teacher engagement with textbooks is predominantly with fidelity, two important issues should be considered, not at the level of utilisation of the textbooks, but at the conceptualisation thereof: (a) the content of the mathematics textbooks should mirror and interpret the topics/concepts prescribed in the curriculum for a specific grade, and (b) the teacher guide should provide meaningful pedagogical support for teachers. My assumption is that a rigorous interpretation of the mathematics curriculum in the textbook and a meaningful pedagogical support in the teacher guide is likely to stimulate teachers' engagement with textbooks. In fact, having textbooks where content is interpreted thoroughly in the textbook and pedagogy is rigorous in the teachers' guide could benefit teachers who use them with fidelity and those who use them by adapting them. I concur with Brown (2011)

that the shift from engaging with textbook with fidelity rests upon the extent to which curriculum materials such as the textbooks (and teacher guides) guide the teacher. This, therefore, implies that the journey to advance meaningful teachers' engagement with textbooks starts at the conceptualisation and writing of textbooks. Based on this view, I propose four interrelated dimensions of the framework (Figure 16) that could be considered when writing textbooks, thereby ensuring meaningful teacher engagement with textbook. The proposed framework consists of the *textbook,* the *teacher guide,* the *teacher, and* the *learner (TTTL).*

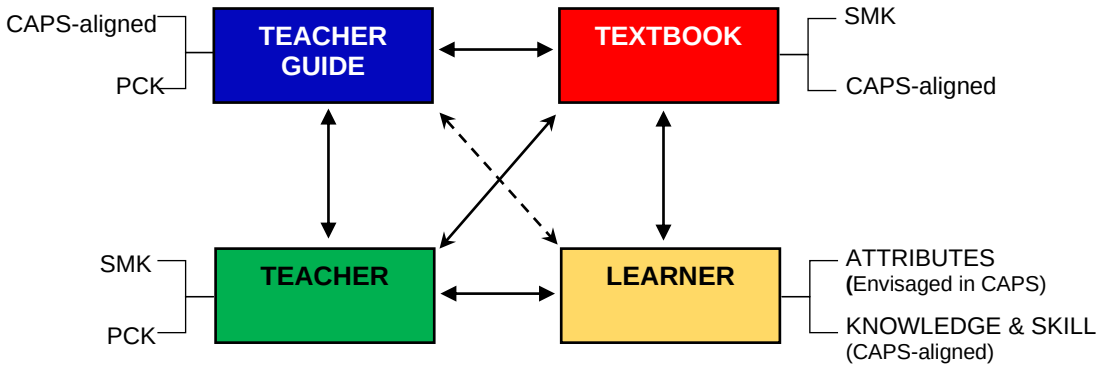


Figure 16: Proposed framework for textbooks conceptualisation

The MKT framework by Ball et al. (2008) assisted me design the suggested TTTL framework above. This framework suggests how the textbook and the teacher guide should be conceptualised for teachers to undergo a paradigm shift from textbook engagement through *offloading* to meaningful *adaptation* of textbook activities resulting in effective planning and teaching of mathematics. In the next paragraphs I explain what each of the dimensions of the proposed textbook conceptualisation framework entails:

The textbook dimension

Textbooks must be written in such a way that they fit like a puzzle to curriculum policy. Textbooks should focus on the SMK domain of the MKT framework. However, since CCK focuses on the basic mathematics knowledge that anyone (not necessarily a teacher) can have, the two kinds of content knowledge specific to teaching that should feature prominently in the textbook are Ball et al.'s. (2008) SCK and HCK. Regarding SCK, textbooks should be rich in content knowledge and this knowledge should enable

teachers to visualise the embedded constituents of a mathematical procedure. For example, calculation plans involved in generating a general rule in *patterns*, teachers should understand why procedures work and why some do not work. Pertaining to HCK, textbooks should be written in such a way that teachers and learners are able to understand how mathematical ideas and topics taught within the grades curriculum and beyond are integrated. This will assist as teachers in this study could not meaningfully integrate *patterns* with other topics. The content in the textbook, therefore, should inform the pedagogical guidance provided in the teacher's guide.

The teacher guide dimension

Teacher guides should be rich in pedagogy to assist the teacher enact the curriculum as envisaged by curriculum policy to produce the learner that the policy envisages. However, the teacher guides' relationship with learners in this study is implicit because learners do not directly interact with teacher guides but, learners benefit from teacher guides through teachers' instructional practices guided by the teacher guide. When teachers were asked how the teacher guides assisted them, one teacher responded: *It does not guide us as it is written as a teacher guide... but it give us answers*. For KCS, teacher guides should: assist the teacher think of what learners think about the concept being taught, enable teachers to adapt activities meaningfully to suit the teaching approach and the learning environment, accommodate different learners' learning styles. Regarding KCT, some of the components of the teacher guides should: clearly indicate the objectives of the unit, present symbolic and visual representations of the concepts, relationships, and procedures, clearly indicate mathematical tasks to be presented to learners and give pedagogical guidance to the teacher. In the teacher guide, there should be an indication of where the topic is found in the policy, possible learner errors/misconceptions with possible mitigation, and brief discussions on tracing the concept or topic in terms of the extent to which it was taught in the previous grade and the extent to which it will be taught in the next grade should also be reflected in the teacher guide so that teachers do not have to verify concepts in the policy. This will assist teachers develop lesson plans that are rich in content and pedagogy as Remillard (2018) states that teachers' pedagogical design capacity (PDC) is essential in designing a valid and reliable *learning proposal*.

The teacher dimension

Brown (2011) argues that the shift from *following* rests upon the extent to which curriculum materials such as the textbook and teacher guides guide the teacher. Through teacher engagement with the suggested components of the textbooks and teacher guides, I believe that both the teachers' SMK and the PCK domains with their respective sub-domains would improve. This in turn, will enable teachers to shift from teaching through *following* from the textbook to meaningful *adaptation* (Remillard, 2005) and *interpretation* (Brown, 2011) of the mathematics activities. This I believe over time will then advance to the last perspective of teacher-text relationship which Brown (2011) referred to as *participating with* where teachers create their own meaningful and relevant activities. Hence, the learner envisaged by policy is likely to be realised.

The learner dimension

South Africa's mathematics curriculum (CAPS) stipulates the kind of a learner envisaged to be one who can, inter alia, think critically and creatively, solve problems effectively, and work collaboratively with others. Therefore, the effectiveness of policy implementation for learners to meaningfully learn, rests on the kind of process that teachers undergo when they engage with textbooks during lesson planning and lesson presentation. In turn, the effectiveness of teacher engagement with textbooks rests on how textbooks and teachers' guides are written. Teacher guides provide teachers with relevant information needed to effectively teach the concepts and activities written in the textbook. If textbooks are written in such a way that they assist the teacher with content (what) and pedagogy (how), teacher engagement with textbooks would improve their *pedagogical design capacity* and therefore produce the learner envisaged by policy. This means, if teachers are aware of the kind of the learner that is envisaged by policy and the textbooks (including the teacher guides) are educative to guide their teaching, both the teachers' SMK and the PCK would positively shift towards the production of the learner envisaged by policy. This shift will imply that learners are taught knowledge, skills and values that equip them to match the learner envisaged by policy.

6.4 Limitations

Data was supposed to be collected from March 2020 but due to the coronavirus outbreak, the country underwent lockdown level 5. Henceforth, I was only able to collect data at the

beginning of 2021. In as much as data were eventually collected, the process was delayed by a year.

There was general anxiety among teachers during the lesson planning stage and during lesson presentation and observation stage of Lesson Study. My sample consisted of eight Grade 6 mathematics teachers but, due to some of them being infected and affected by covid-19, only one out of three lesson planning sessions had the full complement of the sample. Some on certain days tendered apologies for not being able to attend the collaborative lesson planning session due to covid-19 related illnesses and /or their respective family members diagnosed covid-19 positive resulting in the rest of the family members quarantining. Some came late on certain days because they first had to teach their rotational classes before they leave. However, there is no session that started with less than six teachers forming a reasonable number of participants rotational timetable brought by the implementation of social distancing in the classroom.

The venue for data collection compromised the smooth flow of the process during lockdown level 2. Contributing factors to this were namely, (a) due to rotational timetable, schools were full because they had used all the floor space that they have to accommodate social distancing, (b) schools did not allow outsiders on their premises other than the designated learners and teachers. As a result, data were collected at the District Teacher Development Centre (DTDC). The centre was flooded with all subject advisors and their respective teachers and as a result, there was a lot of noise outside with occasional interruptions.

Teachers' travelling to the central venue also limited the time scheduled for lesson planning because not all teachers would not arrive on time due to transport issues since not every teacher had a car. If Lesson Study PLCs could be formed within the school, such challenges could be mitigated. In addition, although asked teachers to view me as one of them and relax as I collected data, the fact that I am their subject advisor may have had some subtle shyness and discomfort that may have impaired on free discussions. In the same way as a researcher, there could have been some subtle gestures or tones that might have caused teachers' discomfort.

Since one of the research questions of this study delt with the teacher learnings that took place as a result of their (teachers) engagement with the textbook, this construct (teacher learning) could have been meaningfully and reliably measured quantitively instead of only

qualitatively. For instance, the study could have included the quantitative aspect of SMK and PCK where teachers could be subjected to pre/post-test i.e. before and after their participation in Lesson Study, especially in collaborative lesson planning. In this way the extent of their learnings could be statistically measured and perhaps explained qualitatively. To this effect, mixed method approach would have yielded more insights in this study.

One mitigating strategy to the spread of covid-19 at schools was 1,5 metres social distancing. Schools had to space out desks in their classrooms to accommodate social distancing, therefore splitting the original number of learners to smaller groups depending on the capacity that the classroom floor space would allow. Learners' parents had signed the assent forms before the outbreak of coronavirus. As a result of the class split, not all learners that had signed the assent forms were part of the observed lesson presentation. In addition, teachers were fully occupied as there were more classes to teach due to splits because of social distancing, it was hard for teachers to leave their learners and come to DTDC especially since learners had been at home for over three months without receiving any tuition. The starting time in many instances was also delayed by the teachers that were occupying the same room before us if they took a bit longer to finish their own agenda. This impacted on the time spent with teachers to such an extent that I had to offer myself to transport one teacher who commuted using one common transport with other teachers from the same school or neighbouring schools (club transport) to maximise her participation in the lesson planning session.

6.5 Recommendations

Through this study, I have gained insight into how teacher engagement with textbooks in the context of LS afford them (teachers) opportunities to learn knowledge and skills from which the learners benefit. Not only did LS afford teachers an opportunity to learn but, it also created a human support structure for mathematics teaching. I have also gained an understanding that individual teacher engagement with the textbook does not yield the same teacher and learner benefits as collaborative teacher engagement with the textbook both in terms of teaching and learning and teacher professional development. Firstly therefore, I recommend that LS should be adopted as an institutionalised teacher professional development model. In particular, the issue of *kyozai-kenkyu* should be a common feature when teachers plan a lesson, because it is at the heart of teacher

professional learning. It is through kyozai-kenkyu where teachers study curriculum materials such as textbooks that they gain deep and shared understanding of mathematics content and they learn new ways of teaching that content. Through, this study's findings, I have deeply understood the effect that textbooks and teacher guides have in the process of mathematics teaching and learning. This reconceptualization stems from, *inter alia*, (a) mathematics teacher-text relationship with fidelity (b) the skeleton structure of the teacher guides, (c) teacher awareness of the coherence between intended and implemented curriculum.

Secondly, I recommend that there should be a mathematics textbook conceptualisation framework to guide the writing of both the textbooks and the teachers' guides to shift teacher-text engagement with the textbook from fidelity to *adapting* or *interpreting*. Remillard (2005) asserts that teachers need to be mathematically fluent for them to be able to shift from being transmitters of knowledge to designers of knowledge. In this case, pedagogically rich teacher guides and textbooks would improve teachers' mathematical knowledge thereby improving their mathematical fluency. I reckon the second and the third mode of teacher-text engagement with the textbook by Brown (2011) and Remillard (2002) namely, *adapting* and *interpreting* respectively is the minimum teacher-text engagement mode needed to produce the learner envisaged by policy. As a result, I proposed the TTTL framework for textbook development and recommend that this framework could be explored further during the development of textbooks.

Thirdly, I recommend that more detail should be added onto the mathematics teacher guides in terms of pedagogy so that they fully assist the Grade 6 mathematics teacher that may or may not have specialised in mathematics.

Lastly, I recommend that what teachers need to know from the CAPS be reflected on the teacher guide so that even if they do not consult the curriculum policy often (as this study depicts), the information that is communicated by curriculum policy is related to teachers through teacher guides.

6.6 Epilogue

At the time of undertaking this research journey, I was familiar with LS and had already introduced circuit-based LS to teachers in my district. Some lessons and new realizations surfaced as I journeyed through my research. I learnt that in-school LS, unlike circuit-wide

LS, is preferable because of two major benefits: (1) it enables all teachers to meaningfully participate in professional development sessions as compared to one teacher attending a workshop and in turn, be required to share information with the other teachers of the same discipline who had not attended the workshop due to contextual constraints; and (2) it mitigates against logistical challenges such as leaving one's school early to meet with other teachers to attend the LS session. In addition, I have gained better understanding of the teachers' challenges in teaching numeric and geometric patterns.

This research did not only benefit me personally but, it also benefited me professionally because it helped me to re-think the support given to teachers. Through this study, I realized the importance of teacher-led and practice-embedded professional development. I have a better understanding of how teachers engage with textbooks, the limitations of the current textbooks (including teacher guides) in our schools, and how the textbooks and teacher guides could be improved so that they may be productively used by teachers during lesson planning and lesson presentation.

6.7 Conclusions

This qualitative study undergirded by the interpretivist paradigm emerges from the premise that although textbooks are the significant resources that mathematics teachers use, there is no uniform framework to guide the writing and screening of them. As a result, the writing of textbooks is subject to the publisher's interpretation of the CAPS which may create many variations to textbook contents. Hence, this study sought (a) to explore Grade 6 mathematics teacher engagement with textbooks during the lesson planning and lesson presentation/observation stages of the LS cycle and (b) to elicit teacher awareness of the coherence between the intended and the implemented curriculum. The use of the Mathematics Knowledge for Teaching (MKT) framework comprising of both the SMK and the PCK by Ball et al. (2008) as a lens to view teacher engagement with the textbook in the context of LS enabled me to observe the teachers SMK and the pedagogy used to deliver the content. This framework explored the mathematics knowledge for teaching that Grade 6 mathematics teachers use or do not use while interacting with the textbook during the above-mentioned stages of LS to ascertain how teachers engage with the textbook. Collecting data through observation of the two LS stages and where necessary corroborating with interviews enabled me to witness the phenomenon first hand. Findings revealed that during lesson planning, as teachers engaged in the study of textbooks

(*kyozai-kenkyu*), they learn both the use and/or develop their SMK and PCK. Regarding the SMK dimensions, teacher use the SCK when interacting with activities from the textbook but, they also learn new SCK from fellow teachers through their engagement with textbook selected activities, for example, as they worked out solutions to the answers, decreasing patterns and, reverse calculations of functional relationships. Teachers' HCK seemed to lack as they could not meaningfully link *patterns* to other relevant concepts or topics.

Out of the five textbook series used during lesson planning, four textbook series displayed geometric calculation plans of finding the general rule that converted a geometric pattern to a numeric pattern and only one textbook series used the semi concrete structure of a pattern given to derive the general rule and focussed mainly on teaching mathematics for understanding. Again, in as much as the study was not about comparing textbooks, lack of the framework to guide the writing and screening of textbooks create inequalities in terms of learning opportunities. Hence, in as much as teachers had their own KCT, more could have been learnt if the teacher guides had some pedagogical detail in them and not just the answers. However, teachers learnt the methodology from the textbook as well as the questioning style. This could also promote the correct use of mathematical language. Although teacher engagement with the textbook was with fidelity, they superficially adapted the activities because as they were planning the lesson, they had a learner in mind (KCS), but they seemed to accommodate the slow learner more than any other learner in the classroom. As teachers tried to refer and verify certain aspects, they seemed unfamiliar with policy because they took very long trying to navigate the CAPS. They were quick to refer to textbooks even of the previous grade than CAPS. In as much as they seemed unfamiliar with CAPS, they seemed very sure of the coherence between the policy and the textbook. This also showed the trust that teachers have in the textbook.

In conclusion, I assert that like blood running through the veins of a living organism to give it life, so are the mathematics textbooks running through mathematics teacher engagement with them to produce the learner envisaged in the curriculum policy. Mathematics textbooks need to assist teachers with the mathematical knowledge that they need for them to meaningfully enact the curriculum. Since teacher engagement with textbooks was predominantly with fidelity, textbooks need to be written in such a way that teacher engagement with them shifts from infrequent superficial adaptation to frequent meaningful and purposeful adaptation of textbook activities. Teacher guides need to

incorporate significant aspects that teachers need to know from policy so that, even if teachers do not open the CAPS, no information is lost. Hence, I propose the TTTL framework that if considered, could assist in the uniform development of textbooks, and possibly close the identified gaps. Even though I understand that the TTTL framework would need to be tested before it is validated, I posit that should textbooks be written guided by the TTTL framework, deep conceptual understanding of the curriculum would be promoted as compared to shallow coverage of the curriculum. This would, therefore, enable the education system to produce the type of a learner envisaged by policy and competent in the global world.

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Annexure A: Nexus between the research questions, the MKT framework and selected LS stages

RESEARCH QUESTION	MKT FRAMEWORK		
	Domain	Sub-domain	Lesson Study stage
(1) How do mathematics textbooks contribute to teachers' understanding of *patterns*?	SMK	CCK	Lesson planning
	SMK	SCK	
(2) How do teachers use of mathematics textbook activities inform instructional decision-making during collaborative lesson planning?	SMK	SCK HCK	Lesson planning
	PCK	KCT KCC KCS	• Lesson planning • Lesson presentation
(3) To what extent does teacher engagement with textbook elicit their awareness of coherence between the intended (CAPS) and implemented curriculum (textbooks)?	PCK	KCC	Lesson planning
(4) How do teachers use textbooks during lesson presentation?	SMK	SCK	Lesson presentation
	PCK	KCT KCS	

Annexure B: Observation instrument – lesson planning

Research question	DESCRIPTION	COMMENTS
How do mathematics textbooks contribute to teachers' conceptual understanding of *patterns*?	• Understanding of the attributes of geometric patterns and numeric patterns • Learning of methods of teaching the concept (s) on patterns from the textbook. (KCT) • Learning calculation strategies on patterns using the textbook(s)	
How do teachers use of mathematics textbooks activities inform instructional decision-making during collaborative lesson planning?	Discussing and deciding on: • most likely responses from all learners in class (KCS) • the purposeful activities to facilitate teaching and learning (KCC) • the scope (depth and breadth) of the topic/concept. (SCK) Fidelity/adapting/improvising	
To what extent is teacher engagement with textbooks eliciting awareness of coherence between the intended and implemented curriculum?	• Compliance of selected activities to policy prescripts (SCK, KCC) • Awareness of vertical and horizontal horizon. Fidelity/adapting/improvising	

Annexure C: Observation instrument for lesson presentation

OBSERVATION ASPECT	DESCRIPTION	COMMENTS
How do teachers use textbooks during lesson presentation?	• Referring learners to the textbook to emphasise what was taught. • Textbook used for classwork and homework. • Using the explanations in the textbook(s) to explain concepts. • Fidelity/adapting/improvising	

Annexure D: Teachers' demographics

Please respond to the following questions by ticking the box:

1. Gender?

☐ Male ☐ Female

2. Age?

☐ 21 to 27 years ☐ 28 to 35 years ☐ 36 to 45 years ☐ 46 and above

3. As a teacher, what are your qualifications in education? (You may tick more than one box)

☐ Certificate or diploma ☐ Bachelors' degree ☐ Masters' degree ☐ Doctoral degree ☐ Other

4. For how many years have you been a mathematics teacher?

☐ 0 to 5 years ☐ 6 to 10 years ☐ 11 to 15 years ☐ 16 and above

5. In which phases have you taught? (*You may indicate more than one phase*)

☐ Foundation Phase ☐ Intermediate Phase ☐ Senior Phase ☐ FET Phase

6. Have you attended previous professional development mathematics workshops?

☐ Yes ☐ No

Annexure E: Ethics-related annexures

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

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear District Director

Name of the District: _____

REQUEST FOR PRMISSION TO CONDUCT A RESEARCH STUDY

I am a student at University of Pretoria, and I am conducting a doctoral study titled **Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.** The purpose of the study is two-pronged: firstly, to explore teachers' engagement with Grade 6 mathematics teaching and learning materials, specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the LS cycle, and secondly, to establish teachers' awareness of coherence between the intended curriculum and implemented curriculum as presented in the CAPS and the textbooks respectively. This letter serves to request your permission to conduct research study amongst Grade 6 Mathematics teachers of the selected schools that are implementing Lesson study in the district. CMC manager, circuit manager(s) and principals of selected schools will also be given a letter of request.

If permission is granted, teachers will participate in this study by:

1. being observed during two of the five stages of Lesson Study cycle i.e. *lesson planning stage* and *lesson presentation & observation* stage. A total of five lessons will be observed and video recorded.
2. being part of the **interview** session (30 minutes) that will be video recorded.

Note that their *participation is* completely *voluntary* and if they agree to participate, I will ensure that the following ethical principles are adhered to:

- *Informed consent:* their consent to participate is based on their understanding of the purpose and process of the study as I have explained them.
- *Safety in participation:* they will not be exposed to any risk or harm of any form.
- *Privacy*: Their names and the data they provide will be kept confidential and anonymous. We also would request their permission to use their data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

- *Trust*: they will not be subjected to any act of deception or betrayal in the research process or its published findings.

For any additional information, you may contact me, Nomvuyo Thobela, at (082 560 7111) or my supervisor, Dr RD Sekao at 012 420 4640 or david.sekao@up.ac.za

Yours sincerely

_____ _____

Ms NM Thobela (Student) Dr RD Sekao (Supervisor)

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

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear Circuit Management Centre Manager

Name of the CMC: _____

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

I am a student at University of Pretoria, and I am conducting a doctoral study titled **Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.** The purpose of the study is two-pronged: firstly, to explore teachers' engagement with Grade 6 mathematics teaching and learning materials, specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the LS cycle, and secondly, to establish teachers' awareness of coherence between the intended curriculum and implemented curriculum as presented in the CAPS and the textbooks respectively. This letter serves to request permission to conduct research study in the circuit amongst mathematics teachers of the selected schools that are implementing Lesson Study. Principals of selected schools and their circuit managers will also be given a letter of request.

If permission is granted, teachers will participate in this study by:

1. being observed during two of the five stages of Lesson Study cycle i.e. *lesson planning stage* and *lesson presentation & observation* stage. A total of five lessons will be observed and video recorded.
2. being part of the **interview** session (30 minutes) that will be video recorded.

Note that their *participation is* completely *voluntary* and if they agree to participate, I will ensure that the following ethical principles are adhered to:

- *Informed consent:* their consent to participate is based on their understanding of the purpose and process of the study as I have explained them.
- *Safety in participation:* they will not be exposed to any risk or harm of any form.
- *Privacy*: Their names and the data they provide will be kept confidential and anonymous. We also would request their permission to use their data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.
- *Trust*: they will not be subjected to any act of deception or betrayal in the research process or its published findings.

For any additional information, you may contact me, Nomvuyo Thobela, at (082 560 7111) or my supervisor, Dr RD Sekao at 012 420 4640 or david.sekao@up.ac.za

Yours sincerely

_____ _____

Ms NM Thobela (Student) Dr RD Sekao (Supervisor)

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear Circuit Manager

Name of the Circuit: _____

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

I am a student at University of Pretoria, and I am conducting a doctoral study titled **Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.** The purpose of the study is two-pronged: firstly, to explore teachers' engagement with Grade 6 mathematics teaching and learning materials, specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the LS cycle, and secondly, to establish teachers' awareness of coherence between the intended curriculum and implemented curriculum as presented in the CAPS and the textbooks respectively. This letter serves to request permission to conduct research study in the circuit amongst mathematics teachers of the selected schools that are implementing Lesson Study. Principals of selected schools will also be given a letter of request.

If permission is granted, teachers will participate in this study by:

1. being observed during two of the five stages of Lesson Study cycle i.e., *lesson planning stage* and *lesson presentation & observation* stage. A total of five lessons will be observed and video recorded.
2. being part of the **interview** session (30 minutes) that will be video recorded.

Note that their *participation is* completely *voluntary* and if they agree to participate, I will ensure that the following ethical principles are adhered to:

- *Informed consent:* their consent to participate is based on their understanding of the purpose and process of the study as I have explained them.
- *Safety in participation:* they will not be exposed to any risk or harm of any form.
- *Privacy*: Their names and the data they provide will be kept confidential and anonymous. We also would request their permission to use their data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.
- *Trust*: they will not be subjected to any act of deception or betrayal in the research process or its published findings.

For any additional information, you may contact me, Nomvuyo Thobela, at (082 560 7111) or my supervisor, Dr RD Sekao at 012 420 4640 or david.sekao@up.ac.za

Yours sincerely

_____	_____
Ms NM Thobela (Student)	Dr RD Sekao (Supervisor)

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear Principal

Name of the school: _____

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

I am a student at University of Pretoria, and I am conducting a doctoral study titled **Mathematics teacher engagement with textbooks during the Lesson Study session**. The purpose of the study is two-pronged: firstly, to explore teachers' engagement with Grade 6 mathematics teaching and learning materials, specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the LS cycle, and secondly, to establish teachers' awareness of coherence between the intended curriculum and implemented curriculum as presented in the CAPS and the textbooks respectively. This letter serves to request permission to conduct research study in your school amongst selected mathematics teachers who are implementing Lesson Study. In addition, you are kindly requested to accept the Lesson Study group involved in this study to visit your school for lesson presentation and observation should your school be selected as the host school. Teachers are invited to participate in this study by:

3. being observed during two of the five stages of Lesson Study cycle i.e. *lesson planning stage* and *lesson presentation & observation* stage. A total of five lessons will be observed and video recorded.
4. being part of the **interview** session (30 minutes) that will be video recorded.

Note that their *participation is* completely *voluntary* and if they agree to participate, I will ensure that the following ethical principles are adhered to:

- *Informed consent:* their consent to participate is based on their understanding of the purpose and process of the study as I have explained them.
- *Safety in participation:* they will not be exposed to any risk or harm of any form.
- *Privacy*: Their names and the data they provide will be kept confidential and anonymous. We also would request their permission to use their data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.
- *Trust*: they will not be subjected to any act of deception or betrayal in the research process or its published findings.

For any additional information, you may contact me, Nomvuyo Thobela, at (082 560 7111) or my supervisor, Dr RD Sekao at 012 420 4640 or david.sekao@up.ac.za

Yours sincerely

_____ _____

Ms NM Thobela (Student) Dr RD Sekao (Supervisor)

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Faculty of Education

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear Mathematics teacher

INVITATION TO PARTICIPATE IN THE RESEARCH STUDY

I am a student at University of Pretoria, and I am conducting a doctoral study titled **Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.** The purpose of the study is two-pronged: firstly, to explore teachers' engagement with Grade 6 mathematics teaching and learning materials, specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the LS cycle, and secondly, to establish teachers' awareness of coherence between the intended curriculum and implemented curriculum as presented in the CAPS and the textbooks respectively. This letter serves to request you to participate in the aforementioned research study.

You are therefore invited to participate in this study by:

1. being observed during two of the five stages of Lesson Study cycle i.e. *lesson planning stage* and *lesson presentation & observation* stage. A total of five lessons will be observed and video recorded.
2. being part of the **interview** session (30 minutes) that will be video recorded.

Note that your *participation is* completely *voluntary* and if you agree to participate, I will ensure that the following ethical principles are adhered to:

- *Informed consent:* your consent to participate is based on your understanding of the purpose and process of the study as I have explained them.
- *Safety in participation:* you will not be exposed to any risk or harm of any form.
- *Privacy*: Your names and the data you provide will be kept confidential and anonymous. We also would like to request your permission to use your data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.
- *Trust*: you will not be subjected to any act of deception or betrayal in the research process or its published findings.

For any additional information, you may contact me, Nomvuyo Thobela, at (082 560 7111) or my supervisor, Dr RD Sekao at 012 420 4640 or david.sekao@up.ac.za

Yours sincerely

Ms NM Thobela

Dr RD Sekao (Supervisor)

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
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Faculty of Education

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear Ms Thobela

LETTER OF CONSENT TO PARTICIPATE IN THE RESEARCH STUDY

I,……..……., voluntarily and willingly agree to participate in the study titled: **Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.** I understand that my participation in the afore-mentioned study to which I am consenting, will involve:

1. being observed during the two of the five stages of Lesson Study cycle i.e., *lesson preparation stage and lesson presentation & observation* stages
2. Being part of the **interview** session (30minutes) that will be video recorded.

I declare that I understand, as you explained to me, the purpose of the study and that you subscribe to ethical research principles, including the following:

- *Informed consent*: Based on my understanding of the purpose and process of the study as it was explained to me. I will, therefore, not be coerced into participating in the study.
- *Safety*: I will not be exposed to any risk or harm of any form.
- *Privacy*: My name(s) and the data/information I provide will be kept confidential and anonymous. My name will not be revealed in any publication or any other method through which the findings of this study will be disseminated.
- *Trust:* I will not be subjected to any act of deception or betrayal in the research process or its published findings.

In addition, I grant the University of Pretoria permission to use data I will provide for this study, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

Given the above information, I give consent to voluntarily participate in the study.

(**Name** and **surname**)	Signature	Date

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear Parent

REQUEST FOR YOUR CHILD TO PARTICIPATE IN THE RESEARCH STUDY

I am a student at University of Pretoria, and I am conducting a doctoral study titled **Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.** The purpose of the study is two-pronged: firstly, to explore teachers' engagement with Grade 6 mathematics teaching and learning materials, specifically textbooks during collaborative lesson planning and lesson presentation/observation stage of the Lesson Study cycle, and secondly, to establish teachers' awareness of coherence between the intended curriculum and implemented curriculum as presented in the CAPS and the textbooks respectively. This letter serves to request permission to allow your child to be the teacher's audience on the days the study is conducted within a normal school day

If permission is granted, your child will participate in this study by being observed during two of the five stages of Lesson Study cycle i.e. *lesson planning stage* and *lesson presentation & observation* stage. A total of five lessons will be observed and video recorded. Please note, your child will be exposed to this session only on one day since different schools will be hosting the lesson. Lessons will be videotaped your child will not be blurred out in the video nor his/her response be muted as these may precede the teacher's interaction with the textbook, which will be the focus of analysis and not the learners. However, should you not grant permission for your child to be part of these lessons, your child will be taken to another class group of the same grade and if a school has one class per grade, your child will be taken to Grade 5 for the duration of the lesson.

The study is focussing on how teachers engage with the textbook and therefore your child's activities in the classroom will be selectively used in this study – if they impact on the teachers' use of the textbook.

Note that their *participation is* completely *voluntary* and if you agree on your child's behalf for them to participate, I will ensure that the following ethical principles are adhered to:

- *Informed consent:* their consent to participate is based on your understanding of the purpose and process of the study as I have explained them.
- *Safety in participation:* they will not be exposed to any risk or harm of any form.
- *Privacy*: their names will be kept confidential and anonymous. The confidentiality and privacy applicable to this study will be binding on future research studies.

- *Trust*: they will not be subjected to any act of deception or betrayal in the research process or its published findings.
- For any additional information, you may contact me, Nomvuyo Thobela, at (082 560 7111) or my supervisor, Dr RD Sekao at 012 420 4640 or david.sekao@up.ac.za

Yours sincerely

_____ _____

Ms NM Thobela (Student) Dr RD Sekao (Supervisor)

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Faculty of Education

Enq: Ms N Thobela
JY Building
08 Main Street
Kokstad, 4700
Email: nomvuyothobela@gmail.com

Dear Ms Thobela

LETTER OF CONSENT TO PARTICIPATE IN THE RESEARCH STUDY

I,……..……., voluntarily and willingly agree for my child to participate in the study titled: **Mathematics teachers' engagement with textbooks: the affordances of Lesson Study.**. I understand that his/her participation in the afore-mentioned study to which I am consenting, will involve:

1. Being observed during lesson presentation at his/her school
2. Use of video recording in the classroom of which my child will not be the focus

I declare that I understand, as you explained to me, the purpose of the study and that you subscribe to ethical research principles, including the following:

- *Informed consent*: Based on my understanding of the purpose and process of the study as it was explained to me. My child will, therefore, not be coerced into participating in the study.
- *Safety*: My child will not be exposed to any risk or harm of any form.
- *Privacy*: His/her name will be kept confidential and anonymous. His/her name will not be revealed in any publication or any other method through which the findings of this study will be disseminated.
- *Trust:* My child will not be subjected to any act of deception or betrayal in the research process or its published findings.

Given the above information, I give consent for my child to voluntarily participate in the study.

(**Name** and **surname**) - Parent	Signature	Date

(**Name** and **surname**) - Learner