An analysis of summative assessment in Grade 9 mathematics School-based examinations

by

George Tshegofatso Manamela

Submitted in fulfilment of the requirements for the degree

MAGISTER EDUCATIONIS

in the Faculty of Education

at the

UNIVERSITY OF PRETORIA

Supervisor: Dr RD Sekao

April 2023

Declaration

I, George Tshegofatso Manamela (15194681), declare that the dissertation titled: "**An analysis of summative assessment in Grade 9 mathematics school-based examinations"** which I hereby submit for the degree Magister Educationis at the University of Pretoria, is my work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Ethical Clearance Certificate

Faculty of Education

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	CLEARANCE NUMBER: **EDU008/22**
DEGREE AND PROJECT	MEd An analysis of summative assessment in Grade 9 mathematics school-based examinations
INVESTIGATOR	Mr George Manamela
DEPARTMENT	Science Mathematics and Technology Education
APPROVAL TO COMMENCE STUDY	28 March 2022
DATE OF CLEARANCE CERTIFICATE	07 September 2022
CHAIRPERSON OF ETHICS COMMITTEE:	Prof Funke Omidire
CC	Mr Simon Jiane Dr R.D Sekao

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

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

Ethics statement

The author, whose name appears on the title page of this dissertation, has obtained, for the research described in this work, the applicable research ethics approval. The author declares that she has observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for Researchers and the Policy guidelines for responsible research.

Name: GEORGE TSHEGOFATSO LAMAMEGA.

Signature: .... G.T

Dedication

I dedicate this research to my son (Oreabetse Usemuhle Manamela), who was born during my Master's research journey and was a constant source of inspiration and motivation. I hope you will be proud of what your father has accomplished.

Acknowledgements

To have achieved this milestone in my life, I would like to express my sincere gratitude to the following people:

- Dr R.D. Sekao, my research supervisor, I would not have seen this far if it was not for his invaluable advice, guidance and patience.
- My family and friends who have always been by my side.

Abstract

Various factors are cited for general unsatisfactory performance in school mathematics in South Africa. Learners usually achieve better outcomes when they are assessed through assessments that are developed within the school than through the assessments developed externally. A case in point in terms of external assessment is the unacceptably low levels of performance of South Africa's learners in Trends in Mathematics and Science Study (TIMSS) and/or the now defunct Annual National Assessment (ANA) contrasted with their performance in school-based examinations. The discrepancy brings to question the 'quality' of school-based summative assessment.

The aim of this study was to investigate the extent of alignment between Grade 9 mathematics school-based summative assessments and the prescripts of the Curriculum and Assessment Policy Statement (CAPS). To achieve this, an interpretivist qualitative case study was undertaken involving three mathematics summative examination from schools in Limpopo provice. I used Mathematics Knowledge for Teaching (MKT) framework and the CAPS taxonomy of cognitive levels as the theoretical lenses to analyse mathematics examinations. Qualitative data were collected through document analysis and the questions were analysed using a rubric of cognitive levels and content areas.

Findings revealed that Grade 9 school-based mathematics examinations from the three schools are not aligned with CAPS. Thus, revealing the educators' lack of comprehension of CAPS and deficiency in MKT. Considering the aforementioned information, recommendations for future research and practice were made. This study could afford teachers, policymakers and researchers a different angle through which to appreciate the low levels of performance among Grade 9 learners.

Key words: *cognitive levels, mathematics assessment, mathematics knowledge for teaching, school-based assessment, summative assessment*

EDITORIAL CERTIFICATE

This document certifies that the Master's Dissertation listed below was edited for proper English language, grammar, punctuation, spelling and overall style by Kingstone Language Editing Services, *professional language writing editors based in Hatfield, Pretoria*.

DISSERTATION TITLE

'An Analysis of Summative Assessment in Grade 9 Mathematics School - Based Examinations'

AUTHOR

GEORGE TSHEGOFATSO MANAMELA

FACULTY OF EDUCATION

UNIVERSITY OF PRETORIA

DATE ISSUED

15/11/2022

Kingstone Language Editing Services
353 Festival Street, Hatfield
Editing Consultant, Francis Kintu
francis kintu

KINGSTONE LANGUAGE EDITING SERVICES

List of abbreviations

ANA	Annual National Assessment
CAPS	Curriculum and Assessment Policy Statement
CCK	Common Content Knowledge
DBE	Department of Basic Education
FET	Further Education and Training
GET	General Education and Training
HCK	Horizon Content Knowledge
KCC	Knowledge of Content and Curriculum
KCS	Knowledge of Content and Students
KCT	Knowledge of Content and Teaching
MKT	Mathematics Knowledge for Teaching
NAEP	National Assessment of Educational Progress
NOR	Numbers, Operations, and Relationships
NSC	National Senior Certificate
OECD	Organisation for Economic Cooperation and Development
PFA	Patterns, Functions, and Algebra
PCK	Pedagogical Content Knowledge
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SBA	School-Based Assessment
SCK	Specialised Content Knowledge
SMK	Subject Matter Knowledge
TIMSS	Trends in International Mathematics and Science Study

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: GENERAL ORIENTATION

1.1. INTRODUCTION

Mathematics is considered a key subject across many nations. In countries with developing economies like South Africa, mathematics subject is considered vital for social and economic advancement (Bosman & Schulze, 2018; Makgato & Mji, 2006). However, poor learning outcomes in mathematics education in South Africa are much talked about and thus cannot be neglected. According to Bansilal (2017), the unsatisfactory mathematics learning outcomes in South Africa is witnessed each year at the release of the Grade 12 National Senior Certificate (NSC) results that are always met with widespread criticism, because they show little to no sign of improvement. It is not surprising that the Department of Basic Education (DBE) recognized that the problem with the poor state of mathematics education starts long before learners enter Grade 12, and as a result, the now defunct Annual National Assessment (ANA) was introduced in 2011 across various earlier grades including in Grade 9 to improve the learning outcomes in mathematics and language subjects (DBE, 2011).

Despite the intervention by the DBE, learner achievement in mathematics continued to be underwhelming, particularly in Grade 9 where the ANA reports of 2012, 2013 and 2014 showed that the national average pass percentages in mathematics for the three years were 13%, 14% and 11%. Sadly, since the discontinuation of ANA eight years ago, South Africa does not have national assessments for the General Education and Training (GET) phase (Grades 1-9). This state of affairs leaves the education system to rely on school-based assessment.

A host of large-scale international assessments in mathematics, particularly the achievement in these assessments, supported the view that the state of mathematics education in South Africa is anything but dire (Spaull & Kotze, 2015). Even though Howie (2012) describes South Africa as a relative latecomer in the scene of international assessments, having only started to participate in international assessments after 1994 (post-apartheid), it does not provide any form of justification for the persistent underperformance in mathematics in international assessments. According to Taylor (2013) South Africa participates in two major international assessments for mathematics; Trends in International Mathematics and Science

Study (TIMSS), and the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ). Out of the two major international assessments, TIMSS initially measured Grade 8 mathematics achievement in South Africa in 1995, 1999, and 2003 (Taylor, 2013). South Africa took a brief hiatus from TIMSS in 2007, with the government and the national organizers of TIMSS citing many different reasons for non- participation. The year 2019 marked the sixth time that South Africa participated in TIMSS, now with Grade 9 learners instead of Grade 8 leaners who have been excluded from the study since 2011, the reason for changing the testing grade was said to be because of the overall underperformance in earlier studies of TIMMS (TIMSSSA, 2015).

The Grade 9 learners could only manage to assume the second last spot in the mathematics study of 2011 (Juan, Reddy & Arends, 2020). However, as with former studies the latter studies indicate that South Africa's performance remains underwhelming in mathematics. Juan, Reddy and Arends (2020) report that South Africa was near the bottom of the list of poor-performing countries in the latest TIMSS mathematics study of 2019 as was also the case in the TIMSS study of 2015.

1.2. PROBLEM STATEMENT

The skills that mathematics educators have in developing and administering acceptable learner assessments were identified as being of poor quality (Bansilal, 2017). In contrast to international testing discussed in earlier paragraphs, assessment at the school level (school-based assessment) is more rooted in the teaching and learning process (Braun & Kanjee, 2006). Chetty (2016) reported that these assessments were usually developed and administered by teachers, school principals and other teaching staff. I extend this view, to subject specialists, subject facilitators and circuit managers. Perhaps the characteristic that mostly distinguishes school-based assessment from international tests is that the former is more aligned with the enacted curriculum, although they may be of low standard as compared to international tests (Chetty, 2016).

In their study, Van der Berg and Shepard (2015) found that teachers develop learner assessments that are of a poor standard at schools and as a result low-quality feedback is communicated to learners and parents. Moodaly (2010) investigated assessments developed by 32 Mathematics teachers and found that 84% of the questions in all the administered assessments required cognitive skills of lower grades than the ones specified in the tests. Berger, Bowie & Nyaumwe (2010) used the Subject Assessment Guideline for Mathematics (SAGM), which they refer to as a tool used for evaluating Grade 12 mathematics examination, to investigate the alignment of the examinations with the curriculum. A lack of alignment between the two was revealed. If this was the case with the high-stake Grade 12 examination, one can assume that the situation could be dire in the lower grades. Furthermore, to indicate that assessment has been a neglected and long-standing issue in education, Vandeyer and Killen (2003) revealed that teachers were struggling to deal with the assessment requirements of former curriculum policies in South Africa. The issue of educators struggling with assessment requirements was still prevalent in the current curriculum with little being done to address it (Maharajh, Nkosi & Mkhize, 2016).

1.3. PURPOSE AND RATIONALE

The primary purpose of the current study was to explore summative assessment in the General Education and Training (GET) phase with a focus on Grade 9 mathematics in South Africa to determine the extent to which the examinations are aligned with the prescripts of CAPS (DBE, 2011). This includes the range of cognitive levels and the scope of content that guides teaching, learning and assessment in public schools. Essentially, the primary purpose of my study is to analyse the school-based summative assessment involving Grade 9 mathematics examinations. Broadly, the unit of analysis is two-pronged: (1) analysing adherence to the cognitive levels, and (2) analysing adherence to the scope entrenched in content areas of mathematics. Each of these units of analysis is disaggregated into two research questions to address the primary research question (§ 1.4).

The lived experiences I had as a mathematics educator also drove me to the realization that summative assessment is an important yet complicated part of teaching and learning. Summative assessment requires a critical consideration and interpretation of the curriculum. As such, looking into the extent to which educators adhere to the prescripts of CAPS given the amount of time that has elapsed since it was first introduced in 2011 was also very important. It will give insight into how well teachers are coping with interpreting the contents of the intended curriculum. This study will contribute to the improvement efforts of educators, policy makers, and researchers.

1.4. RESEARCH QUESTIONS UNDER INVESTIGATION

1.4.1. Primary research question

What is the extent of alignment between the Grade 9 mathematics summative assessment and the prescripts of CAPS?

1.4.2. Secondary research questions

The following secondary research questions were used to respond to the primary research question:

a) To what extent do the questions in Grade 9 mathematics examinations address the cognitive levels of questions prescribed in the CAPS?
b) How are the questions in the Grade 9 mathematics examinations spread in relation to the percentile weighting prescribed in CAPS?
c) To what extent do the questions in Grade 9 mathematics examinations address the content areas prescribed in CAPS?
d) To what extent do the questions in the Grade 9 mathematics examinations assess the scope of content as specified for Grade 9?

1.5. CLARIFICATION OF CONCEPTS

Educator

Educator refers to any person who teaches learners/pupils at any of the public schools in South Africa and is appointed legally in a post under the Employment of Educators Act (1998). While the term ‘teacher’ is used globally, in South Africa a *teacher* is also referred to as an *educator*, therefore I have used the term *educator* as a synonym of *teacher* in this study.

Learner

This term refers to any person that qualifies to receive education or is required to receive education in terms of the South African Schools Act (SASA) (1996). While the terms pupil and student are used globally, in the South African context the term *learner* is broadly used; therefore, I have used the term *learner* as a synonym of *pupil/student* in this study.

School-Based Assessment (SBA)

School-Based assessment refers to all forms of assessment (classroom assessment, informal/formal assessment and formative/summative assessment) that are fully developed and controlled by the educator(s) against a set of outcomes at school (Dube-Xaba & Xulu, 2020). This term is contrasted with the term external assessment.

Senior Phase

This term refers to the third phase consisting of Grades 7, 8 and 9 in the schooling system in Sounth Africa (DBE, 2011).

1.6. THE LITERATURE REVIEW

Although I have reviewed the literature in detail in Chapter 2 to gain insights into the already existing studies appropriate to my study title, in this section I present an overview or glimpse of what Chapter 2 entails.

1.6.1. The context: summative assessment

The contents discussed under this sub-heading bring forth the different ways presented in the literature of defining summative assessment. The broadest definition of summative assessment embodies summative assessment as a process of collecting interpreting and reporting evidence of learning at a particular time during the learning process (Dolin, Black, Harlen & Tiberghian, 2018). The process of conducting the summative assessment is normally prescribed in the curriculum, such as in the CAPS document.

1.6.2. Summative assessment in mathematics education

Summative assessment particularly in South African mathematics education is discussed. The DBE (2011) dictates that summative assessment take place after a single topic or a group of interrelated topics in the form of assignments, investigations, projects, tests and examinations. Considering this Suurtman et al. (2016) and Bansilal (2017) undertook studies which revealed that summative assessment was mostly overlooked and at times examiners' way of presenting summative assessment was inconsistent with the prescripts of the curriculum.

1.6.3. Perspectives on mathematics cognitive levels of questions

Literature on cognitive levels of questions revealed that cognitive levels are used to show how different learners of a particular age cope with the mathematics test questions at their level (Pournara, Mpofu & Sanders, 2015). The test questions are typically classified according to what is called the 'cognitive levels' of questions. In South Africa the DBE introduced the Subject Assessment Guidelines for Mathematics (SAGM) to serve as guidance when classifying test questions into cognitive levels, the four cognitive levels that questions can be classified into are (a) Knowledge, (b) Routine Procedures, (c) Complex Procedures, and (d) Problem-Solving.

1.6.4. Guidelines for developing mathematics summative assessment

This section of the literature review pertains to mathematics assessment frameworks that have been developed to guide examiners in developing appropriate mathematics summative assessments. Some publications that present mathematics assessment frameworks are Trends in International and Science Study (TIMSS), National Assessment of Educational Progress (NAEP), and The Organization for Economic cooperation and Development (OECD). The main use of the mathematics assessment frameworks is to layout aspects that must be in the assessments such as the context and style of questions (NAEP, 2019). The SAGM of South Africa serves the purpose described in the previous statement.

1.6.5. The role of MKT in mathematics assessment

Mathematics Knowledge for Teaching (MKT) provides an important lens through which to think about mathematics teachers and their work (Chapman, 2013). The theory of MKT became prominent through Shulman's (1986) seminal work. Shulman (1986) proposed two domains of knowledge for MKT: (a) Subject Matter Knowledge (SMK) and (b) Pedagogical Content Knowledge (PCK). MKT is the knowledge of mathematics content used to respond to the daily demands of teaching the subject in the classroom (Phelps & Howell, 2016). A lack of MKT implies a lack of adequate knowledge to teach mathematics, thus, consequently, the teachers that lack MKT cannot feasibly develop and administer acceptable mathematics summative assessments (Ball et al. 2008).

1.6.6. The theoretical framework

Flowing from the literature that was reviewed, I opted to approach the study through two theoretical lenses. The theoretical lenses are: (a) Cognitive levels and content areas prescribed in the mathematics curriculum (CAPS), and (b) Mathematics knowledge for teaching (MKT) advocated by Ball et al. (2008) and evolved from the seminal work of Shulman (1986). The CAPS present four cognitive levels, each with a descriptor, and a prescribed weighting (DBE, 2011). In addition, CAPS lists five main content areas in Grade 9 for mathematics, also with a descriptor of content for each, and a prescribed percentile weighting (DBE, 2011). On the other hand, MKT is the knowledge that teachers need to have to successfully teach mathematics (Ball et al. 2008). This specialized mathematics knowledge (MKT) is split into two broad categories, namely: (a) SMK and (b) PCK. The two categories of mathematics knowledge respectively comprise of three knowledge domains. SMK consists of Common Content Knowledge (CCK), Specialized Content Knowledge (SCK), and Horizon Content Knowledge (HCK), while PCK is grounded by Knowledge of Content and Teaching (KCT), Knowledge of Content and Students (KCS), and Knowledge of Content and Curriculum (KCC).

1.7. RESEARCH METHODOLOGY

The methodology chapter of the current study was guided by the research onion as advocated for by Saunders, Lewis, and Thornhill (2019). Moreover, the research methodology is dealt with in detail in chapter three.

1.7.1. Philosophy

The first layer that needed peeling off (to be addressed) in terms of Saunders' et al. (2019) research onion was the research philosophy, which lays the foundation of ontology and epistemology. The current study was guided by the interpretivist research philosophy.

1.7.2. Approach to theory development

The research approach was the second layer of the current research study that needed peeling off. I had to choose between the inductive approach, which leads to qualitative research methods, and the deductive approach, which leads to quantitative research methods (Sahay, 2016). Although the current study had few characteristics of deductive research (those that involve working with numbers as percentile weightings), I opted to adopt the inductive research approach which lead to qualitative research methods discussed under the next layer of the research onion.

1.7.3. Methodological choice

The methodological choice section formed part of the third layer of the research onion that needed to be uncovered. I opted to adopt qualitative research methods over quantitative research methods and mixed methods. Qualitative research aims to obtain meaning by describing situations (McCusker & Gunaydin, 2015).

1.7.4. Strategies

The research strategies (the fourth layer of the research onion) describe the strategy/strategies that I adopted in carrying out the research. Regarding the current study, I adopted the case study research strategy, which is also consistent with the nature of social science studies.

1.7.5. Time Horizons

The fifth layer, time horizons regarded the period of the study. Two time periods are suggested by Saunders et al. (2019) cross-sectional time horizon and longitudinal time horizon, the former is for short-term studies, while the letter is for long-term studies. The current study is of a cross-sectional time horizon.

1.7.6. Techniques and procedures

The sixth and final layer of the research onion comprises the techniques and procedures that I followed in conducting the current study. The techniques and procedures layer involve the selection, collection and analysis of data (Abdelhekim, 2021). In selecting the data that formed part of this study, three mathematics year-end examinations were conveniently and purposefully selected due to easy access and geographical proximity to myself.

The collection of the data in the current study was handled through document analysis, which, is a systematic procedure used to review and/or evaluate electronic or printed documents (Wood, Seber, & Vecchio, 2020). The documents under review in the current study consisted of the CAPS document, Grade 9 mathematics examinations, and in some instances, their memoranda. In addition, two data collection instruments (see Appendix A and Appendix B) were created to assist me to collect the data.

Regarding the analysis of the data, I was confronted with a choice between two common and often interchangeable data analysis methods: qualitative content analysis and thematic analysis (Vaismoradi, Turunen, Bondas, 2013). Even though the current study had traits that required thematic analysis, Vaismoradi et al. (2013) advise that qualitative content analysis has more potential to qualify and quantify data as was necessary for this current study. As such, I chose qualitative content analysis as my main method of data analysis.

1.7.7. Quality Criteria

To demonstrate and enhance quality, I identified four key concepts namely, credibility, transferability, dependability, and conformability.

1.7.8. Ethical considerations

To ensure ethical accountability the Grade 9 mathematics examination question papers from the three schools in the same educational circuit in Limpopo province were treated as valuable as possible. Furthermore, permission was sought from the respective schools to use their Grade 9 mathematics examination papers in the current study. Lastly, the names of the schools, circuit, and district were concealed using pseudonyms.

1.8. THE OUTLINE OF THE CHAPTERS

The whole study is organized into five chapters which are briefly described in the next section.

Chapter 1: Introduction

Chapter one of the current study presents the introduction to the study, reveals the problem which necessitated my research, and then the purpose and rationale of this study. Furthermore, research questions under investigation are outlined and concepts are clarified. Lastly, a brief background of the study is provided with an outline of the chapters of the current study.

Chapter 2: Literature review

In this chapter (Literature review) relevant literature related to the study title, especially summative assessment in mathematics education, is reviewed. I also reviewed other variables related to summative assessment such as cognitive levels and the scope of content as presented in the enacted curriculum, i.e., Curriculum and Assessment Policy Statement (CAPS), mathematics assessment frameworks, and the mathematics knowledge teachers need to teach mathematics and assess learners.

Chapter 3: Research methodology

In this chapter, I present the methods and procedures that I followed to answer the research questions that guided this study. The structure of the methodology chapter was guided by the research onion by Saunders, Lewis, and Thornhill (2019) (Figure 3.1). The layers of the research onion that I discussed include my research philosophy, research approach, methodological choice, research strategy, time horizons, and the techniques and procedures I employed in my study. Lastly, I discussed the quality criteria to ensure the trustworthiness of the data, and the ethical considerations I followed to heighten ethical research practices.

Chapter 4: Findings

In this chapter, I present the findings of the current research study. The findings were mainly guided by the cognitive levels of questions as well as the scope of content prescribed in the CAPS for Grade 9 (DBE, 2011). Furthermore, the findings were guided by MKT knowledge domains that teachers need to respond to everyday teaching tasks, and for the most part, those tasks involve assessing learners.

Chapter 5: Discussions, recommendations and conclusions

In this chapter, I discuss the implications of the findings relating to the cognitive levels as they pertain to sub-questions one and two, and the scope of content as it pertains to sub-questions three and four. I also reflect on the affordances of the theoretical framework as a glue that bound the different aspects of the study together. Furthermore, I outlined the limitations that may have been a hindrance to my study and made recommendations for examiners, policy makers and researchers. The chapter ends with conclusions that also answer the primary research question of this study.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

A review of literature provides an all-inclusive overview of the literature that is related to a research topic and combines the findings of prior research studies to build up the foundation of knowledge within present studies (Paul & Criado, 2020). Relevant literature from prior studies is carefully identified and integrated into the study so that comparisons and contrasts can be made (Paul & Criado, 2020). Because of this, in this chapter relevant literature related to summative assessment in mathematics education is reviewed, the chapter also reviews other variables related to summative assessment such as cognitive levels and the scope of content as presented in the enacted curriculum, i.e., Curriculum and Assessment Policy Statement (CAPS), mathematics assessment frameworks, and the mathematics knowledge teachers need to teach mathematics and assess learners. By so doing, a futuristic understanding of the topic for the reader is fulfilled. This implies that the reader will understand the topic according to modern times. In addition, the chapter discusses cognitive levels as well as mathematics knowledge for teaching (MKT) as they frame the current study.

2.2 THE CONTEXT: SUMMATIVE ASSESSMENT

Assessment can be defined in many ways. It can be defined as a deliberate effort made to observe learners' amount of learning through different means to get a sense of where the learners are concerning one or more specific learning objectives (Gao, Li, Shen & Sun, 2020). Islam and Stapa (2019) describe assessment in a generic sense by asserting that it refers to a wide range of tools or techniques used by teachers to document learners' progress towards learning, gaining skills, learning needs, and preparedness. However, there have been numerous researchers who have provided an authentic way of defining assessment as an ongoing process that involves the collection, review, interpretation, and use of information about learners' achievement to enhance and develop their learning (Brown & Hirschfield, 2008; Kivunja, 2015; Moss, 2013). The data is collected through written accounts such as examinations, it is reviewed through the marking process by the teacher, the interpretation of the results relates to the conclusions that can be made, and lastly, this information may be used to make improved instructional decisions. This definition reveals that assessment is a collaborative venture; a daring journey towards learning undertaken by teachers and learners.

How educators carry out the process of assessment depends on the purpose, which could be the diagnostic, formative, or summative purpose (Kapukaya, 2013). Diagnostic assessments are used to identify knowledge and skills gaps in specific subjects (DBE, 2018). Furthermore, the information obtained from diagnostic assessments is used to inform the content that is to be delivered to learners in order to fill those gaps (DBE, 2018). This definition suggests that diagnostic assessments are administered before any formal learning and teaching can take place. For instance, before commencing to teach the theorem of Pythagoras in Grade 9 it might be useful to set up a diagnostic assessment that will help with identifying what learners already know about the sub-topic. When this is established, the teacher will be able to make better instructional choices based on the needs of the learners.

Formative assessment involves collecting learners' knowledge to make immediate instructional choices, the information is collected through different activities such as group discussions, classroom discussions with the teacher, reflective questions, and monitoring the learners through classroom and home activities to obtain information that will assist the teachers to adapt their teaching to meet their learners' needs (Bacquet, 2022). Based on this definition it can be assumed that formative assessment takes place during the teaching/learning process. Unlike assessments that are diagnostic or formative, summative assessments happen at the end of the process of learning (Kibble, 2017; Dixson & Worrel, 2016). In terms of its focus, summative assessment is also defined as a means of determining whether the examinees (the learners) are ready to be promoted to the next level of learning (Harrison, Konings, Wass, & Schuwirth, 2015).

The definition aligns well with the definition of summative assessment according to its purpose towards the teaching and learning process, that is; summative assessment serves the purpose of providing a summary of the learning that has taken place, to assign grades, certify, or record learner progress (Waugh & Gronlund, 2013). An even broader definition is given by Moss (2013) who states that summative assessment is a tool used to determine overall learner achievement in a specific learning area at a particular point in time of the learning process. Similarly, according to Dolin, Black, Harlen, and Tiberghien (2018) assessing learners summatively involve collecting, interpreting, and reporting evidence of learning at a particular time. Moreover, the interpretation of this evidence of learning is concerning the intended goals, normally prescribed in the curriculum, that learners are supposed to have achieved at a certain point in time such as at the end of the year, semester, or schooling term (Dolin, Black, Harlen & Tiberghien, 2018). The current study will investigate those summative assessments in mathematics that are administered at the Grade 9 level during the year-end period.

2.3 SUMMATIVE ASSESSMENT IN MATHEMATICS EDUCATION

According to the Department of Basic Education (2011), summative assessment in South African mathematics education is intended to take place in the learning process after a single topic or a group of interrelated topics, in the form of assignments, investigations, projects, tests and examinations. The focus of this study is on the examination as a form of assessment in mathematics. Literature by Connor et al. (2018) suggests that when information gathered from the assessment is used effectively to improve teaching and learning, learner gains can be increased in mathematics. Teachers will be able to identify gaps that need to be filled in their delivery of instruction. Although examinations may take place at the end of the year when a particular group exits a specific grade i.e. Grade 9, the information obtained from the outgoing group can be used to better prepare for the incoming group. In support, it is further articulated by Veldhius and Heuvel-Panhuizen (2019) that when assessment is a part of the teaching and learning that takes place in the classroom it aids the teachers to better understand the learners.

Therefore, assessment is not just there to form part of regular teaching and learning as a task to be completed by the teacher and learners, it is there to give direction and to steer the teaching and learning that takes place. In their study on assessment in mathematics education, Suurtman et al. (2016) assert that strong deliberation should be made on whether and how assessment tasks assess the appropriate complex nature of mathematics and the standards of the curriculum being assessed. It is further claimed by Moss (2013) that the authenticity of a summative assessment depends on the quality of the assessment and that of the assessor. Simply put, a good quality assessment is most likely to be developed by a good quality teacher. However, research seldom investigates the 'actual contents' of summative assessments in mathematics that are developed at schools, which according to me reflect the parts of mathematics that are important for learners to learn at a particular level of their development. Gezer et al. (2021) investigated the relationship between formative assessment and summative assessment in mathematics for primary grade learners (Grades 1-7) consisting of two groups of teachers and learners, the first group consisted of 27 teachers and 258 learners while the second group consisted of 50 teachers and 477 learners. Their study revealed a positive relationship between formative assessment results/data and summative assessment results, meaning that learners that performed well in formative assessments also showed a good performance in the summative assessment that was used for comparison. This study revealed mostly that effective formative assessment practices have mostly positive outcomes towards summative assessment gains.

Although summative assessment is the least used between the two forms of assessment in the classroom, its capacity as a driving force/tool that can improve instruction in the classroom was overlooked. More especially because the contents and importance of the summative assessment were shunned in contrast with the contents and attributes of the formative assessment. CAPS for mathematics in the Senior Phase (Grades 7 to 9) highlights five main content areas that are important for learners to learn at the Grade 9 level, as well as an indication of how the content should be spread (i.e., scope) in Grade 9 mathematics examination (Department of Basic Education, 2011). The five content areas of focus in Grade 9 mathematics include (a) Numbers, operations, and relationships; (b) Patterns, functions, and algebra; (c) Space and Shape (Geometry); (d) Measurements; and (e) Data-handling.

Furthermore, the content areas are allocated a weighing of 15%, 35%, 30%, 10% and 10% respectively. According to CAPS, the weighing of mathematics content areas in the manner discussed serves the purpose of guiding the time needed to adequately address the content and most importantly it guides with the spread of content or the scope in the examination (especially end-of-year summative assessment) (Department of Basic Education, 2011, p. 11).

The lack of alignment between assessment, particularly summative assessment and the prescripts of the curriculum has been a long-standing issue in South African mathematics education. For instance, after the introduction of CAPS and the ANA, Pournara, Mpofu and Sanders (2015) presented a content analysis on the first three ANA papers taken in Grade 9 for mathematics with specific attention to cognitive levels and difficulty levels across the test items. In their content analysis Pournara et al. classified cognitive levels quite differently from how the test developers had classified them on the sampled test items, fewer questions in the content analysis had a low level of cognitive demand than was expected by the DBE.

In an almost similar study conducted by Bansislal (2017) the results of the mathematics ANA obtained by leaners in Grade 9 were compared to their school-based assessment (SBA) in the form of end-of-the-year examination results. SBA refers to the various ways used by teachers to formally or informally assess learners using different methods, tools, and contexts on an ongoing basis in the classroom (DBE, 2019). This multiple case study involving five well-performing schools, showed that learners' results in their final examination were strongly correlated with their results in the ANA; however, their scores for the SBA were much higher than the scores obtained in the ANA, leading to the conclusion that the CAPS and the ANA were not designed for the average learner in South Africa (Bansilal, 2017). Notwithstanding Bansilal's conclusion, I think the findings could also imply that the SBA examination was pitched at a lower level, hence the high scores.

2.4 PERSPECTIVES ON COGNITIVE LEVELS OF QUESTIONS

The levels of cognitive demand on items in mathematics assessment show how different learners of a particular age experience and get to grips with those items (Pournara, Mpofu & Sanders, 2015). This implies that in this current research, strong assumptions about typical Grade 9 learners in South Africa must be made. Earlier research that analysed the levels of cognitive demand of items in mathematics assessment focused mostly on comparisons of 'textbooks' in terms of two prominent categories (1) mathematics content and topics and (2) cognition and pedagogy (Bautista & Isoda, 2017). This leads to content, structure and often learners' performance being the centre of attention, neglecting the most significant item about assessment, its quality which is regarded as being directly proportional to leaner achievement. Moreover, early research on this topic shows that when analysing mathematics assessments, researchers believed in classifying items in the assessment according to taxonomies now referred to as levels of cognitive demand. Stein and Smith (1998) believed that the items in mathematics assessment could be classified into four broad levels: memory, procedures without connections, procedures with connections, and doing mathematics. Contrary to this, Potter (2002) did not share the same view of classifying the individual assessment items, rather he classified mathematics assessment items in assessments into four levels: memory, performing procedures, communicate and understanding.

The then Department of Education in South Africa (DBE) introduced the Subject Assessment Guidelines for Mathematics (SAGM) to guide assessment in mathematics (Department of Education, 2008). In the SAGM four taxonomical differentiation of questions are identified and include knowledge, routine procedures, complex procedures, and problem-solving – each with specified descriptors. Notably, the SAGM taxonomy of cognitive levels was derived from the cognitive domains of the 1999 TIMSS mathematics survey (TIMSS Database User Guide, 1999). Despite the subsequent curriculum reviews in South Africa, the same cognitive levels are still maintained in the current curriculum – the Curriculum and Assessment Policy Statement (CAPS) for mathematics (Department of Basic Education, 2011).

2.5 GUIDELINES FOR DEVELOPING SUMMATIVE ASSESSMENT

There have been several efforts to describe and present frameworks in assessment, rather, in mathematics assessment. Several 'framework' publications include TIMSS, NAEP, and OECD. Unlike curriculum documents, assessment frameworks can be thought of as supplementary documents to curriculum documents, they contain a layout of the primary design of the assessment by describing the content and type of questions that should be tested and included in the assessment (NAEP, 2019). Assessment frameworks also describe how the various design factors such as mathematics content, mathematics complexity, and item formats and contexts should balance across the assessment (NAEP, 2019).

For assessment developers, assessment frameworks are useful tools in developing anticipated tests, at the school, provincial or even national level.

TIMSS represents a continued long series of Mathematics and Science studies that are conducted by the International Association for the Evaluation of Educational Achievement (IEA) since 1959 (TIMSS Database User Guide, 1999). Given this long history of Mathematics and Science assessment studies, one could argue that the IEA has the most trusted and credible assessment systems in the world. The TIMSS assessment framework has a particular aim of assessing learner achievement in school subjects, with a special view to learning more about the nature and extent of achievement and the context in which it occurs (TIMSS Database User Guide, 1999). According to Robitaille and Garden (1996), as of 1995 TIMSS assessment framework planners chose to focus on curriculum as a comprehensive explanatory factor that underlies learner achievement. This supports the assertion that assessment frameworks should be regarded as companion documents to curriculum documents.

Furthermore, since 1995 TIMSS assessment frameworks for mathematics tests were developed by elite groups of mathematics educators from different parts of the world, who have different perspectives on mathematics (TIMSS Database User Guide, 1999). The frameworks have three different levels, the first is the content aspect that indicates the subject matter for schools, followed by the aspect that focuses on performance expectations, which details the different performances and/or behaviours that may be exhibited by learners in school Mathematics, the last level comprises of the perspectives aspect that is centred around developing learners' attitudes, interests, and motivation within the subject (TIMSS Database User Guide, 1999).

The Department of Basic Education (DBE) in South Africa developed and administered subject assessment guidelines for all 29 learning subjects of the National Curriculum Statement (NCS) including mathematics (DoE, 2008). As expected of any assessment guideline, it is outlined that the mathematics assessment guideline should be used in conjunction with the relevant curriculum statement for the subject (DoE, 2008). The purpose of the SAG is clearly outlined to provide guidance for assessment in the NCS. This means that the SAG allows educators to hone their assessment skills. In addition, the SAG encourages the development of a programme of assessment that consists of tasks undertaken during the school year as well as during the end-of-year examinations. Among other items contained in the Mathematics SAG are the assessment tasks and tools; tests and examinations which use marking memoranda, investigations and projects which may use instruction sheets with rubrics and assignments which may use either the memoranda or rubrics. Although it is claimed in the Mathematics SAG (DoE, 2008) that the order of the tasks is not prescribed, the examinations usually take place in the middle of the year as well as at the end of the year. Lastly, contained in the SAG for Mathematics is the tentative distribution of marks for questions as well as the taxonomical differentiation across questions in the question paper.

2.6 THE ROLE OF TEACHERS' MATHEMATICS CONTENT KNOWLEDGE IN ASSESSMENT

An important way to think about mathematics teachers and their work is through the mathematics knowledge for teaching (MKT) perspective (Chapman, 2013). Some studies describe MKT as the extent to which mathematics teachers showcase their cognitive knowledge of the subject (Holmes, 2012). Whereas Some studies describe and categorize teachers' pedagogical and subject matter knowledge (Ball, Thames & Phelps, 2008; Shulman 1986). Moloto and Machaba (2021) describe MKT as a professional body of knowledge that is specific to the teaching profession (teaching of mathematics) as opposed to the knowledge used in other professions such as accounting and medicine. While Phelps and Howell (2016) view MKT as the knowledge of mathematics content used to identify, understand and respond to everyday mathematical problems encountered in teaching the subject, I argue that this specialised knowledge or a lack of it can be exhibited by teachers through the quality of the summative assessments that they develop.

Hoover, Mosvold, Ball and Lai (2016) bluntly put it that the perspective of MKT lacks a shared, and well-defined conception because of the lack of agreement about definitions, language, and basic concepts. However, there appears to be a broad consensus that a specialised body of knowledge that constantly needs to be strengthened and updated is needed for significant impact on instructional practices in mathematics (Jita & Ige, 2019; Selling, Garcia & Ball, 2016; Mapolelo & Akinsola, 2015; Adler & Vankat, 2014; Holmes 2012). Indeed, there can not be any effective teaching and learning if teachers are not well-equipped with knowledge about the subject they are teaching. Moreover, if teachers do not have enough knowledge about the subject, they cannot feasibly develop and administer acceptable learner assessments. Ball et al. (2008) agree that to make sense of learners' mathematics work and to choose powerful ways to present the subject matter to leaners, teachers need to know the subject beyond procedural and factual knowledge. This means that simply knowing the subject well is not good enough for teaching it. Thus, the need for a specialised knowledge that goes beyond the mathematics that is typically taught to preservice teachers and the mathematics needed by professionals other than teachers (Hoover, Mosvold, Ball & Lai (2016). Since assessment is such an integral part of teaching and learning mathematics, it is important to attempt to look at it from the perspective of MKT

Through the work of Shulman (1986) and ball et al. (2008), two broad categories of knowledge or knowledge domains "subject matter knowledge" (SMK) and "pedagogical content knowledge" (PCK) have been mathematicised under the umbrella of MKT. It was Shulman (1986) who recognized and suggested that the work of teaching requires professional knowledge that is distinctive to the teaching profession. Shulman (1986) proceeded to propose different categories for this specialized professional knowledge for teaching, one of the categories being content knowledge (referred to as subject matter knowledge in this study) while the other category was PCK. Content knowledge referred to having a deep understanding of the structure of the subject beyond the level that learners work on, while PCK refers to aspects of the content that are most relevant in being able to teach the subject successfully (Shulman, 1986).

Ball et al. (2008) also believed that MKT can be divided into two domains of knowledge SMK and PCK. According to Ball et al. (2008), SMK could be further divided into three sub-domains common content knowledge (CCK), specialised content knowledge (SCK), and Horizon content knowledge (HCK). In a nutshell, CCK refers to mathematical content knowledge that is common to everyone, it applies to people that do not teach mathematics (Selling, Garcia & Ball, 2016). For example, the knowledge that multiplication by zero is zero may be thought of as being common with everyone as it is information that people that do not learn/teach mathematics may know. SCK is defined as the mathematical knowledge and skill set that are needed by teachers in their work of teaching mathematics, teachers also utilise SCK when assessing learners (Moloto & Machaba, 2021). For instance, being able to anticipate learner responses out of an assessment to create memoranda, assessing the errors that they make and giving them feedback by explaining back to them in ways that make conceptual sense requires SCK. HCK is the frame of mind that teachers need to have to make ties across mathematics topics, to see where the ideas of learners are headed, and to notice when learners are onto the advanced mathematical point (Ball & Bass, 2008). Shulman (1986) argued that PCK also had subdomains namely knowledge of content and teaching (KCT), knowledge of content and students (KCS) and knowledge of content and curricula (KCC).

The ongoing trend in research on MKT is focused on assessing and creating assessment tools for the MKT that teachers possess (Phelps & Howell, 2016; Selling, Garcia & Ball, 2016; Holmes, 2012). While other research studies focus more on MKT and its impact on classroom practices, which mainly involve the presentation of lessons (hence the creation of lesson plans) and the formation of lesson study groups (Moloto & Machaba, 2021; Jita & Ige, 2019; Mapolelo and Akinsola, 2015; Chapman, 2013). It appears that the area of assessment as a part of MKT is underexplored. Given its importance to teaching and learning, assessment cannot be divorced from discussions of mathematics knowledge needed to successfully teach the subject. Do pertinent issues arise such as what mathematics knowledge do teachers need to know to develop and administer acceptable learner assessments? Where is assessment situated under the umbrella of MKT? As many South African teachers find it hard to master the content of the mathematics that they teach (Bansilal, Brijlall & Mkhwanazi, 2014). The situation can only be dire when they must also develop an assessment for the subject.

2.7 THE THEORETICAL FRAMEWORK FOR THIS STUDY

Flowing from the reviewed literature, I have opted for two theoretical lenses through which to analyse school-based summative assessment, specifically mathematics end-of-year examination. The two theoretical lenses include the: (a) CAPS cognitive levels (DBE, 2011) whose ancestry is traced to 1999 TIMSS cognitive levels (TIMSS

Database User Guide, 1999), and (b) Mathematics Knowledge for Teaching (MKT) (Ball et al., 2008) which evolved from the seminal work by Shulman (1986) on professional knowledge for teaching. I opted for two theoretical lenses because CAPS cognitive levels are the policy standard that teachers need to adhere to when developing mathematics assessment, while MKT is the knowledge that teachers need to carry out the work of teaching mathematics effectively, which involves assessing learners. CAPS states that assessment in mathematics should be appropriate to the age and cognitive levels of the learners. The four cognitive levels are further listed each with its descriptors and approximate weight in assessment (DBE, 2011). In addition, the four levels of cognitive demand described in CAPS are chosen for this study because they are the levels of cognitive demand that educators are expected to adhere to when developing summative assessments, especially an examination.

It is also important to note, that from my lived experiences as an educator, I have gathered that classifying items into taxonomies is never an easy task and that taxonomies are not perfect, they are based on subjective judgements. The cognitive levels as well as MKT as frames for this study are discussed in subsequent paragraphs. The cognitive levels as well as MKT, which constitute a framework in the current study, will assist me in three ways: to collect data, address the research questions and subsequently address the research problem.

2.7.1 Cognitive levels in CAPS

The DBE classifies items in assessment according to four cognitive levels (see Appendix A) namely Knowledge, Routine procedures, Complex procedures, and problem-solving. Firstly, the knowledge level, which can be thought of as having the simplest set of questions, requires; straight recall, use of mathematical facts, identification and direct use of formulas and appropriate use of mathematics vocabulary (CAPS, 2011). In addition, the type of questions within the knowledge domain should be approximately have a weighing of 25%. The knowledge level questions are important for a smooth transition to the other three cognitive levels and for improving learner metacognition (Du Plooy & Long, 2013). However, knowledge questions are often undermined, yet they play a significant role as a foundation for what Kilpatrick (2001) referred to as strategic competency and adaptive reasoning. According to Du Plooy and Long (2013), the knowledge level adds an important element of metacognition, thus, making learners aware of their learning and thinking processes.

Moreover, failure to transition from the knowledge level to the level of the routine procedure, and the complex procedures and problem-solving levels is likely to result in a deteriorating mathematics competence at a higher phase of learning, such as the FET phase.

Secondly, and inconsistent with the knowledge domain, the level of the routine procedure, learners are expected to perform well-known procedures, calculations that may involve many steps, and the use of formulas that may require a change of the subject. Du Plooy and Long (2013) adopted Hiebert's and Carpenter's (1992) description of procedural knowledge as being characterised by having a step-by-step use of actions that manipulate written mathematical symbols. This implies that procedural knowledge bestows in learners the ability to arrive at the answer to a mathematical problem. The mathematics questions rooted within the level of the routine procedure are generally like activities that learners encounter in class, and at 45% weighting, the routine procedures have the highest weighting of all four cognitive levels.

Thirdly, the complex procedure questions consist of questions that require high-order reasoning from the learners, there is no obvious way to find the solution to problems, they require conceptual understanding and elementary axioms need to be investigated so they can be generalized into proofs by learners. Inayah, Septian, and Suwarman (2020) talk about procedural fluency when talking about complex procedures in mathematics. Furthermore, according to Inayah, Septian, and Suwarman (2020) procedural fluency is strongly linked to an understanding of mathematical concepts and problem-solving. Du Plooy and Long (2013) refer to the knowledge needed for complex procedures level as "conceptual grasp". According to Du Plooy and Long (2013), conceptual grasp refers to a group of interrelated ideas that need to be combined to form one big idea, which is conceptualised as one concept, however, this concept is big enough to be split into different sub-concepts in assessment.

Furthermore, Du Plooy and Long assert that mathematics assessments must be created in such a way that they promote the development of conceptual grasp in addition to the straight recall of mathematics knowledge and knowledge of procedures (Du Plooy & Long, 2013). In other understandings, Usikin (2012) describes mathematics as a complex subject which requires detailed processes of teaching and learning, and multifaceted understandings of mathematics portrayals, concepts, application of operations, and understanding of procedures. Considering the description of mathematics provided by Usikin (2012) one can see how important it would be to have questions of the level of the complex procedure in examinations. Moreover, the weight for questions of the level of the complex procedure should be approximately 20%.

Lastly, Problem Solving questions are questions of the highest level of cognitive demand with 10% weighting in the assessment, usually unseen, non-routine, with high-order understanding, and processes involved and may require the ability to break the problem down into parts that make it up. As a result, a deep conceptual understanding is required for questions of the problem-solving level. One gets the sense that the problem-solving level must address the very nature of mathematics; to solve problems (DBE, 2011). In similar understandings, Smith (2016) believes that learning to solve problems is the core principle of studying mathematics. In addition, one of the general aims of CAPS is to produce learners that can recognise and respond to contexts that require 'problem-solving' (DBE, 2011). The CAPS cognitive levels will assist me in the following ways: they will help me collect data from which answers for the first and second sub-questions of this study will be inferred. Therefore, partly addressing the research problem of the study.

2.7.2 Mathematics knowledge for teaching

Ball et al. (2008) define MKT as the knowledge that teachers need to have to respond to everyday demands of teaching mathematics, such as explaining, defining, and presenting concepts to learners, understanding their thinking and ideas, controlling their work, assessing them and being able to predict their responses. This suggests that the work of the mathematics teacher should be carried out effectively. In the context of this current study, assessing Grade 9 learners summatively demands that teachers must be able to exhibit the mathematics knowledge of the many topics and concepts that they teach throughout the year through the examination, such as the scope of content as prescribed in CAPS (DBE, 2011).

By the scope of content, I refer to the five main content areas in the Senior Phase (Grades 7-9) that each contributes towards the acquisition of specific skills by the learners. The five content areas in mathematics include (a) Numbers, operations and relationships (NOR); (b) Patterns, functions and algebra (PFA); (c) Space and Shape (Geometry); (d) Measurements; and (e) Data-handling (DBE, 2011). For Grade 9, the content areas are allocated the weightings of 15%, 35%, 30%, 10% and 10% respectively. As stated in CAPS (DBE, 2011), "the weighting of mathematics content areas serves two primary purposes: guidance on the time needed to adequately address the content within each content area, [and] guidance on the spread of content in the examination (especially end-of-year summative assessment)" (p. 11).

NOR is a content area that involves the manipulation of numbers to achieve required results, to do this, learners need a deep conceptual knowledge of how to use operations, the role of the equal sign, as well as facts about numbers (Bowers, 2021). According to the DBE (2011), The general content focus of NOR is to develop a sense of numbers while the specific content focus of NOR in the senior phase involves; the representation of numbers in different ways, the ability to transition freely between representations, and to 'solve problems' using an increased range of numbers. Competence in the other content areas rests heavily on the knowledge of NOR. Carvalho's and Rodrigues's (2021) assert that competence in NOR is closely linked to the development of 'problem-solving' skills. In similar understandings, Gravemeijer and Muurling (2019), argue that the digital community of the 21st century needs extraordinary mathematical understanding, and this is associated with the development of NOR.

"A central part of PFA is based on the fact that learners must achieve efficient manipulative skills in the use of algebra" (DBE, 2011, p. 10). In addition, the DBE (2011) asserts that the language of algebra can be extended to learning about functions and relationships between variables. One of the importance of learning algebra is that it aids learners to form generalities across situations, specifically mathematics situations (Kaput, 2008). Alibali et al. (2014) suggested that competence in algebra has the likelihood of increasing success in later grades when engaging in more complex mathematics. I extend this view to working across other content areas, this is to say that competence in algebra may increase the likelihood of success in other content areas where generalization across the content areas may be required.

Geometry has been defined in many ways, in one of the definitions is, Geometry involves working with axioms and proofs through deductive thinking (Mamali, 2015). Bassarea (2012) provided another way to talk about Geometry, (Geometry) is the study of shapes, their relationships and properties. According to the DBE (2011), Geometry is the study of space and shape aimed at enhancing knowledge and recognition of the pattern, precision, achievement, and beauty of natural and cultural settings, while the focus is on properties, relationships, orientations, positions, and transformations of two-dimensional shapes and three-dimensional objects. There is a resurgence in the percentile weighting of geometry set out in the DBE (2011) as learners progress through the senior phase (Grades 7-9) highlighting the significance of Geometry as learners progress through the Grades.

Furthermore, the specific content focus of Geometry in the senior phase includes drawings and constructions, the use of constructions to investigate properties of geometric figures, and description and classification categories of geometric figures and shapes (DBE, 2011, p. 10). Geometry is important globally for being a source of visualization for understanding procedures, algebra, and statistical concepts (Binti, Tay, & Lian, 2004). In the scientific world, the importance of geometry is seen naturally in many sectors that include learning about the solar system and geography (Tachie, 2020).

However, there is a decline in learner performance in the content area (Geometry) in South Africa (Chihambakwe, 2017). The decline in learner performance in geometry has been linked to difficulties in learning geometry, and the part of the teachers having difficulties in teaching the content area (Tachie, 2020). It is also important to note that several historical challenges confronting the teaching and learning of geometry have been identified such as the many curriculum reforms after apartheid, geometry not forming a compulsory part of the school curriculums that preceded CAPS, and the prospect of teacher education institutions not offering geometry to trainee teachers (Tachie, 2020). Considering this, Tachie (2020) further asserts that the paucity of literature on how teachers cope with teaching/assessing geometry is a cause for concern since geometry was previously excluded from the curriculum. For the advancement of the economy of the country, Ubah and bansilal (2019), and Alex and Mammen (2018) have identified geometry skills as vital for economic advancement since they are key in construction work, architecture, and engineering.

In the senior phase, measurement focuses on the selection and use of appropriate units, instruments, and formulae that quantify the characteristics of shapes, objects and the environment (DBE, 2011). Specifically, in Grade 9, the focus is on using formulae to measure the area, perimeter, surface area, and volume of geometric figures and solids (DBE, 2011). This means that measurement quantifies the properties of geometric figures. Considering the statement, it is my view that measurement is important in applying the knowledge learned in other content areas apart from geometry, such as NOR and PFA. Furthermore, measurement guides the selection of and cohesion between appropriate units of measurement and allows for the use of the theorem of Pythagoras to solve right-angled triangles problems (DBE, 2011). In the FET phase measurement and geometry are combined to form a content area under the umbrella name ‘Euclidean geometry and measurement’ (DBE, 2011).

In the CAPS policy document, the purpose of data-handling is to enable learners to develop skills to collect, display, organize, and interpret numeric data (DBE, 2011). In learning data-handling learners must interpret data from different contexts to make informed judgments (Odu & Gosa, 2014). North and Scheiber (2008) argued the fact that statistical literacy was important due to all the technological advances taking place globally. According to Odu and Gosa (2014), this argument is what prompted curriculum developers in South Africa to make data-handling an integral part of CAPS.

To effectively assess the content areas, teachers need to invoke their specialised content knowledge. They must also be able to predict learner responses and their reasoning through the memoranda where alternative solutions are provided and considered when marking, therefore, the knowledge of content and students (learners) play an important role. Undoubtedly, undertaking this task would require a teacher with a deep understanding of Grade 9 mathematics, to develop assessment questions that learners will understand, and with relatable concepts as with the ones done in class. Ball et al. (2008) touch on the domains of mathematical knowledge for teaching (already discussed in earlier paragraphs) that teachers need to have to carry out the work of teaching. It appears that teachers require a great deal of information and skill in the mathematics subject matter.

According to Ball et al. (2008), teacher knowledge is divided into two broad domains subject matter knowledge (SMK) and Pedagogical content knowledge (PCK). Three subdomains make up SMK: common content knowledge (CCK), specialised content knowledge (SCK), and horizon content knowledge (HCK). Pedagogical content knowledge also has three subdomains: knowledge of content and teaching (KCT), knowledge of content and students (KCS) and knowledge of content and the curriculum (KCC).

SCK is made up of a deep understanding of mathematics topics, the ability to present this content to learners, as well as the knowledge of the errors that learners might make while working with the content (Ball, Thames & Phelps, 2008). This implies that SCK is knowledge applicable only to teachers. As the test developers, and the ones that spend the most time interacting in the subject with their learners, teachers have the knowledge of the most common errors that the learners might make that will assist in constructing meaningful distractors in questions such as those that involve multiple choices. Furthermore, to present mathematics content to leaners (through the summative examinations) teachers need to have a deep understanding of all the topics beyond the level that any other ordinary person might know. This speaks to the pool of questions and questioning styles that are available to teachers when developing the assessments, when educators deeply understand the topics, one can expect questions that are well structured, fair and with differentiated styles such as multiple-choice questions, direct questions, and mathematics laws questions.

Moloto and Machaba (2021) assert that SCK is distinctive and exceptional since it allows the teacher to apply various problem-solving methods and does not restrict learners' thinking but allows them instead to explore mathematics content. This is vital because the teacher will know what and how to assess. Learners thinking, and imagination will be stretched to greater mathematical heights. It will also allow the teacher to demonstrate (through the memoranda) the various ways of working out the problem. For example, the teacher will not only know when leaner responses are wrong, but with SCK they will be able to understand the root from where the misconception arose and be able to predict responses by typical Grade 9 learners in an examination.

2.8 CONCLUSION

Assessment can be defined in many ways; however, there have been numerous researchers who have provided one sufficient way of defining assessment as an ongoing process that involves the collection, review, interpretation, and use of information about learners' achievement to enhance and develop their learning (Brown & Hirschfield, 2008; Kivunja, 2015; Moss, 2013). One of the roles of educators is to carry out the process which can be for various reasons/purposes; diagnostic, formative and summative (Kapukaya, 2013). The current study aimed to investigate summative assessment developed at school by educators. This is because research seldom investigates content that is within summative assessment developed at school by educators, the focus is mostly on formative assessment (Geza et al. 2021). Furthermore, there is a reported lack of alignment between summative assessment and CAPS (Bansilal, 2017; Pournara, Mpofu, & Sanders, 2015). In CAPS DBE (2011), there is a categorisation of questions into cognitive levels, most notably the SAGM presents four cognitive levels namely knowledge, routine procedures, complex procedures, and problem-solving all of which are derived from TIMSS.

Several framework publications such as the TIMSS, NAEP, and OECD have served as guidelines for developing summative assessments. Another notable aspect of developing summative assessment is the educator's MKT (Ball et al. 2008; Shulman, 1986). MKT is the knowledge that teachers need to do their work of teaching mathematics daily (Chapman, 2013). I argue that it is important to also look at assessment from the MKT point of view, although there is a paucity of literature in the area of assessment as a part of MKT. As a result, I opted for the CAPS cognitive levels and MKT as the theoretical frameworks to guide this study.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter, I present the methods and procedures that I followed to answer the research questions that guided this study. One of the first key things that need addressing is the research methodology (Melnikovas, 2018). The structure of the current chapter was guided by the research onion advocated by Saunders, Lewis, and Thornhill (2019) (Figure 3.1). Onions have layers, these layers must be peeled off to the core by researchers to uncover information and meaning of the situation they are studying (Sinha, Clarke, & Farqhuharson, 2018). To start with, I discussed my philosophical standpoint in conducting the current study. This was followed by a discussion of the research approach, and then the methodological choice. The strategy (research design) as well as the selection of the artefacts (Grade 9 mathematics examination question papers) that formed part of this study, are also discussed. The instruments that were used to collect and analyse the data were also described in detail. The time horizon of the study was discussed. Lastly, the chapter discussed the quality criteria and the ethical considerations that were applicable in conducting the study.

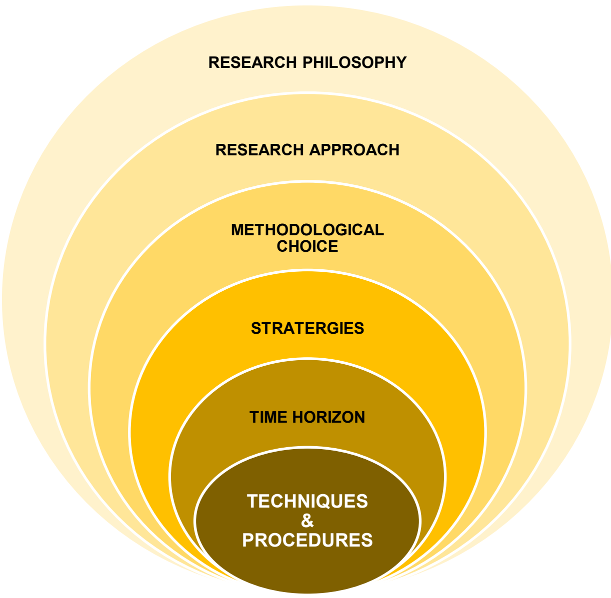


Figure 3.1: Structure of research onion (Saunders, Lewis, & Thornhill, 2019).

3.2 RESEARCH PHILOSOPHY

Peeling off the first layer of Saunders et al.'s (2019) research onion reveals the research philosophy which lays the foundation of the research by providing descriptions of ontology – nature of reality, and epistemology – nature, sources of knowledge or facts. Research philosophies regulate research studies and the discoveries made within them through their assumptions and principles (Park, Konge & Artino, 2020). Even more broadly, research philosophy can be described as the diverse ways of viewing the world and often informing the core from which research is undertaken (Davies & Fisher, 2018; Kivunja & Kuyini, 2017). This implies that a research philosophy entails what I, as the researcher, perceive to be the constituents of the truth, reality, and knowledge.

Furthermore, the design, collection and analysis of data are all guided by the beliefs and values of research philosophies (Gemma, 2018). The current study was guided by the interpretivist philosophy whose ontological perspective assumes that truth, reality, and knowledge are subjective, i.e., they are based on people's lived experiences and understanding thereof (Gemma, 2018). Based on the assumption of subjective truth and reality of a phenomenon being explored, therefore, the existence of multiple realities is inherent in interpretivist philosophy (Myers, 2008). However, the epistemological perspective of interpretivist philosophy assumes that as a researcher I must immerse myself in the site where data is collected to gain in-depth knowledge and understanding of the participants (Rogers et al. 2020).

Consistent with this view, Schwartz-Shea and Yanow (2012) claim that one of the key tenets of interpretivist research is that reality is discovered through the views of the participants, their lived experiences and their background. In similar understandings, research by Thanh and Thanh (2015) explains that research located within the interpretivist research philosophy often looks for experiences, understandings, and perceptions of individuals to unearth information, rather than relying on numbers and statistics. In the current study, human participants are not involved, however, reality and knowledge are revealed through the analysis of Grade 9 mathematics examinations.

My view is that developing an examination by categorising questions according to cognitive levels and content areas can be a complex and multifaceted task, as such, many different interpretations may come to light. Therefore, to gain an in-depth understanding of Grade 9 examinations as a form of summative assessment, I had to conduct an analysis of real examinations that were developed by teachers in teaching practice.

3.3 RESEARCH APPROACH

Linked to the previous layer of the research onion – the research philosophy is the research approach (Melnikovas, 2018). The research onion provides the option of deductive and inductive research approaches (Saunders, Lewis, & Thornhill, 2019). According to Sahay (2016), this is a basic yet essential choice that each researcher must make when conducting their study. In addition, Sahay (2016) asserts that deductive choice leads to quantitative research methods while the inductive choice leads to qualitative research methods. In other instances, Sahay (2016) asserts there can be a need for both (deductive and inductive approaches) leading to a combinative research approach that uses dual methods.

In adopting the deductive research approach, the researcher transitions from the general understanding of a theory to a more specific understanding thereof (Burney & Saleem, 2008). For instance, the implications of a compelling theory such as MKT (theoretical framework in the current study) get tested with data to gain a specific understanding of the theory. The inductive approach moves in the opposite way, the start point is a specific observation followed by a transition toward broader theories and generalizations (Alturki, 2021). When approaching research inductively, Alturki (2021) guides us that the researcher collects the data and then figures out the data patterns and tries to develop a theory to explain those patterns as was the case in this current study.

Therefore, in this study, I combined the two approaches. The theoretical framework (the general understanding of it and pre-conceived ideas that come with it) influenced me in conducting the current study, thus the study is deductive. Moreover, I collected data and deciphered the data in chapter four (findings chapter), thus rendering the study an inductive one. An advantage of adopting the approaches together is that it allowed me to make use of and take advantage of not only qualitative data but also quantitative data.

3.4 METHODOLOGICAL CHOICE

Saunders et al. (2019) define the methodological choice as the technique for collecting and analysing data according to the type of data, whether it consists of numbers (quantitative) or non-numerical (qualitative). “In the research onion, there are six methods: mono method quantitative, mono method qualitative, multi-method quantitative, multi-method qualitative, mixed method simple, and mixed method complex” (Mardiana, 2020, p. 3). however, according to Mardiana (2020), the techniques described in the research onion are based on the primary quantitative and qualitative methods. As a direct implication of the interpretivist research paradigm that I chose for this study, I adopted the qualitative methodological choice.

Although the deductive approach leads to the quantitative choice, the study is mainly qualitative. Qualitative research is associated with circumstances that involve quality, and so does not involve numbers, instead, it describes, applies reason, and mostly makes use of words (McCusker & Gunaydin, 2015). The main aim of the qualitative choice is to obtain meaning in terms of how people feel and by describing situations (McCusker & Gunaydin, 2015). In the context of the current study the main phenomenon that was addressed is the Grade 9 mathematics summative examination and the extent of their alignment to the prescripts of the curriculum. The intention to adopt a qualitative choice also stemmed from the research aims and objectives that were to be achieved in the study, as well as the research questions.

Beyond the affordances of the qualitative choice, some limitations are imminent. First, Silverman (2010) argues that qualitative research approaches often omit contextual sensitivities and focus more on meanings and experiences. The current study focused a lot on my analysis of the Grade 9 examination papers rather than any other imperative issues in the context. Second, policymakers typically give low credibility to findings revealed from the qualitative choice (Rahman, 2020). Sallée and Flood (2012) found that stakeholders (the government, politicians, and policymakers) preferred the use of quantitative research over qualitative research whenever the aid of research is sought. Finally, the analysis of the data in qualitative research takes a large amount of time, and one can generalise the findings to other populations in limited ways (Flick, 2011). For example, if policymakers need to vote on an issue, they need to wait many months for a qualitative study to be conducted (Sallee & Flood, 2012).

3.5 RESEARCH STRATEGY

Peeling away the first four layers, reveals to us the next layer of the research onion; ; strategy. Research strategies can be thought of as the most basic path that will assist the researcher in choosing the main data collection methods or set of methods that will in turn assist the researcher to respond to research questions and meet research objectives (Melnikovas, 2018). Saunders et al. (2019) suggest the following major research strategies: experiment, survey, archival research, case study, ethnography, action research, grounded theory, and narrative enquiry. It is important to note that what Saunders et al. (2019) refer to as research strategies, is what other scholars typically refer to as the research design (Sileyew, 2019; Harris, 2019; Asenahabi, 2019). Moreover, according to Alharbi et al. (2021) the research strategy is selected after careful consideration of the type of data that is needed, available tools and resources, and the kind of resources required. Furthermore, Alturki (2021) claims that the choice of methods and strategies is heavily influenced by the research strategy.

In the current study, I adopted the case study research strategy. Heale and Twycross (2017) suggest that case studies are typical of social science studies like the current one. Although there are different definitions for what a case study is, case studies have been defined simply as intensive investigations about a person, a group, a community, or any other unit where the researcher thoroughly examines data relating to several features of the entity being investigated (Gustafson, 2017). Heale and Twycross (2017) describe how case studies enable researchers to investigate complex situations in their natural setting to increase their understanding thereof. The unit, thing, or entity being studied in this study was the summative assessment of Grade 9 mathematics examinations developed by teachers in three different schools within the same educational circuit in Limpopo province. The complex situation being studied about the examinations was the extent of their alignment to the prescripts of CAPS. Heale and Twycross (2017) assert that, like any other research strategy, case studies have benefits and limitations.

One advantage of using case studies as highlighted by Crowe et al. (2011) is that they can be approached in different ways depending on the research philosophy standpoint of the researcher. In this study, interpretivism was adopted to guide the study so that an in-depth understanding of Grade 9 mathematics examinations can be achieved. Case studies have also been criticised for lacking scientific precision and providing little basis for generalisation (Crowe et al. 2011). This implies that the findings of this study cannot be generalised to larger populations since the case involved only three school-based summative assessments in the form of a Grade 9 examination.

3.6 TIME HORIZON

Any research guided by the research onion can have one of two-time horizons, namely cross-sectional time horizon or longitudinal time horizon (Saunders et al. 2019). "The time horizons can be distinguished through the following question: "Is the research a 'snapshot' taken at a point in time or is it a series of snapshots over a given period?" (Alturki, 2021, p. 6). The time horizon may refer to the period that a study is to be conducted (Melnikovas, 2018). According to Alturki (2021), the time horizon is as a certain period that is covered by a study in conjunction with the time that data were collected, and analysis of the data was conducted. A cross-sectional time horizon reveals the immediate relationship between variables in the research, thus, it is short-term, while a longitudinal time horizon reveals changes in variables and in testing the constancy of the inferences over a long period, thus, making it long-term (Alturki, 2021). The current study has a cross-sectional time horizon, the study is short-term since it will reveal the immediate relationship between the Grade 9 mathematics examination and the prescripts of CAPS. In addition, the changes that may occur after conducting the current study will not be traced beyond the time that the study is conducted.

3.7 TECHNIQUES AND PROCEDURES

The techniques and procedures layer of the research onion includes the selection, collection, and analysis of data (Abdelhakim, 2021; Alturki, 2021).

3.7.1 Research site and sampling

Sampling in qualitative research takes place so that the research questions can be effectively answered, therefore, it is important for the researcher to choose a relevant sample, instead of trying to study the entire population (Taherdoost, 2016). As such, the current study used only three Grade 9 mathematics school-based examinations that were developed and administered by school-based teachers from the same circuit within the same schooling district in Limpopo province. Grade 9 assessment was chosen for analysis instead of other grades because of a series of relatively poor results that were reported in TIMSS and the now defunct ANA. Grade 9 was also chosen because of its position as the exit grade for the Senior Phase (Grades 7-9) in the schooling system in South Africa. All the examinations under analysis were written in November 2021.

The sampling methods that were used for this study are convenient and purposive sampling. According to Singh and Masuku (2013), convenience sampling is described as a non-probability/non-random sampling method where participants or artefacts from the target population that meet a specific criterion such as easy accessibility, willingness to participate or geographical proximity are selected to form part of the study. For convenience, Grade 9 examination question papers from schools proximity to where I am situated were selected to form part of this study. In purposive sampling, a deliberate choice of participants or artefacts is made due to specific qualities that they possess (Singh & Masuku, 2013). Simply put, the researcher decides what information is needed and sets out to find participants or artefacts that can provide that information.

Purposive sampling is associated with qualitative research that seeks to find and choose information-rich cases for maximum utilization in the research (Emmel, 2013). Purposive sampling was used to select Grade 9 examinations because of the consistently poor results in TIMSS and the now defunct ANA as well as the position of the grade as the exit point of the Senior Phase. Essentially, the key inclusion criteria included the grade 9 examination set at school, hence school-based assessment, and end-of--the-year examination used for promotional purposes. One disadvantage of using convenience and purposive sampling highlighted was that the more a study is conducted convenience and purposively the more the study loses its validity (Andrade, 2021). To mitigate this, the validity of the study was enhanced through the quality criteria that I describe in the subsection under the heading (3.7).

3.7.2 Data collection

The collection of data in qualitative research involves choosing and synthesizing linguistic and visual resources that will be used to analyse and comprehend situations, social issues, experiences, and the relational meaning-making process (Flick, 2018). The main aim is to collect data about a situation that a research study is about (Flick, 2018). As such, document analysis was used as my main method of data collection and analysis. Document analysis is a systematic procedure for reviewing or evaluating documents that are printed or electronic (Wood, Sebar, & Vecchio, 2020). The range of documents that may be used includes newspapers, diaries, journals, policy documents, maps, minutes of meetings, books, letters, and memoranda (Wood, Sebar & Vecchio, 2020).

Although document analysis has been used as a complimentary method to other research methods, there have been instances where it was used as a stand-alone method. For example, Wild, McMahon, Darlington, Liu and Culley (2009). In the current study, data was collected through documents that included CAPS, the Grade 9 examination papers and the memoranda. All data sources were used to address the research questions that the study aimed to answer. Specifically, the examination question papers and CAPS addressed all the research questions within this study with the aid of the data collection instruments and the rubrics for data collection.

The first data collection instrument (see Appendix A) which consists of the cognitive levels as specified in CAPS was used to collect data that responded to the first and second sub-research questions. The numbering used in Appendix A is hypothetical since in reality, three examination papers developed by three different teachers are most likely to have different numbering systems. Concerning the first sub-research question - To what extent do the questions in Grade 9 mathematics examinations address the cognitive levels of questions prescribed in the CAPS, the data collection instrument was mainly used to ascertain whether all the prescribed cognitive levels in CAPS were represented in the exam question papers regardless of the percentage (weight) that each cognitive level is represented by. As stated in chapter 2, CAPS prescribes four cognitive levels (see Appendix A) for the Grade 9 mathematics summative assessment, namely, knowledge, routine procedures, complex procedures, and problem-solving. Mathematics teachers are expected to ensure that all four cognitive levels feature prominently when developing summative assessments, particularly the mathematics end-of-the-year examination. It is, thus, expected that at the very least the cognitive levels must be holistically represented in each examination question paper. Regarding the second sub-research question - How are the questions in the Grade 9 mathematics examination spread in relation to the percentile weighting prescribed in CAPS, data were collected (Appendix A) to determine the percentage weight as specified in CAPS. The type of questions within the knowledge cognitive level should approximately have a weighing of 25%, for the level of the routine procedure 45%, for the level of the complex procedure 20% and 10% for the rest of the cognitive levels as they are organised in that order. Lastly, the memoranda served the purpose of providing a beneath-the-surface understanding of questions that may not be easily classifiable into a specific cognitive level at first glance.

The second data collection instrument was used for the third and fourth sub-research questions (see Appendix B). The numbering used in Appendix B is hypothetical since in reality, three examination papers developed by three different teachers are most likely to have different numbering systems. Concerning the scope of content for Grade 9 mathematics, CAPS identifies a total of five key content areas that should be taught and ultimately assessed as discussed in Chapter 2. In addition, there is a percentile weighing that each content area is supposed to assume in the examination. In other words, the data required for the third sub-research question- To what extent do the questions in Grade 9 mathematics examinations address the content areas prescribed in CAPS, is concerned with the general coverage of all the content areas in the examination without considering the percentile weighting. Furthermore, the data pertaining to the fourth sub-research question- To what extent do the questions in the Grade 9 mathematics examinations assess the scope of content as specified for Grade 9? Is concerned with the representation of each content area at the correct percentile weighting.

However, I was mindful of the fact that not everything that was taught ought to be assessed, but what is assessed ought to have been taught. This implies that although every single topic might not be represented, every single topic that is represented should be in line with CAPS. Furthermore, the topics (as questions in the examination) should be pitched at a level that is appropriate for Grade 9 (grade-specificity). For example, when teaching and assessing integers the specification of content for Grade 9 suggests that learners should perform calculations, work with properties of integers and do problem-solving. This is in contrast with the specification of content for Grades 7 and 8 where learners must also count, order, and compare integers (CAPS, 2011). Therefore, a question that involves counting, ordering, and comparing integers in a Grade 9 mathematics examination question paper would suggest that the topic as is being assessed was pitched at a lower level. This requires teachers' knowledge of mathematics content, their knowledge of the curriculum as well as their knowledge of their learners as advocated by MKT (Ball et al. 2008).

It was not the focus of this study to analyse the actual texts and extra-texts (pictures, tables, and sketches) of documents (the Grade 9 mathematics examination papers and memoranda), the focus was on some specific aspect (the alignment of the questions of Grade 9 summative examinations with CAPS). For example, Grade 9 mathematics examination papers were collected for analysis. However, the grammar, spelling and quality of the diagrams and pictures (the actual text) were not the units of analysis, therefore, they were disregarded. Only the questions in the examination papers with reference to the cognitive levels and scope of content were used to guide summative assessment in mathematics in South Africa were analysed (see Appendix A and B).

3.7.3 Data analysis methods

Two commonly used and often interchangeable data analysis methods in qualitative research are qualitative content analysis as well as thematic analysis (Vaismoradi, Turunen, & Bondas, 2013). Qualitative content analysis is a systematic inscription and categorising approach used for analysing large amounts of textual or verbal information modestly to determine trends and patterns of words used, the frequency they are used, their relationship, and structural discourses of communication (Elo & Kyngas, 2008; Grbich, 2012; Marrying, 2004; Pope et al. 2000; Stemler, 2018). In contrast, thematic analysis is viewed as a poorly marked method in the sense that it is not clearly defined as an analysis method as compared with qualitative content analysis as it is simply defined as a method for pointing out, analysing, and delineating patterns within data (Braun & Clarke, 2006). The fact that the methods are often interchangeably used means that it is difficult for researchers to choose between them (Vaismoradi et al. 2013). However, Vaismoredi et al. (2013) discussed the boundaries between them, at first glance, it appears that both qualitative content analysis and thematic analysis are suitable for qualitatively analysing narrative materials by breaking them down to smaller workable units of content and then subjecting them to descriptive treatment. The main difference between qualitative content analysis and thematic analysis was identified to lie in the potential of content analysis to quantify the data (Vaismoredi et al. 2013). This implies that by adopting qualitative content analysis it is possible to qualify data sets and at the same time quantify them. It is also possible to work with percentages and graphical representations such as is the case in this current study without rendering them as quantitative data.

Given this view, I adopted qualitative content analysis to analyse the data that was collected within the study. Specifically, deductive as well as inductive content analysis are used to analyse the data collected. Deductive content analysis involves connecting pre-developed and critically derived aspects of analysis to texts (Stemler, 2018). In the current study, the themes were predetermined, namely, *knowledge, routine procedures, complex procedures,* and *problem-solving*. In addition, the themes as tools that assisted me to analyse the examination papers are drawn from CAPS cognitive levels as described in the theoretical framework. Categorising the questions from the examination paper into these themes was informed by the predetermined descriptors for each theme. Therefore, as I was capturing data on a spread sheet, I was also simultaneously analysing the data.

An inductive approach is also called a data-driven or text-driven approach (Krippendorff, 2013). The driving force behind this analysis method is a search for patterns, during the analysis, the researcher looks for similarities and differences in the data that is described in categories and or themes on various levels of abstraction and interpretation (Graneheim, Lindgren, & Lundman, 2017). In inductive analysis, the researcher moves from data to a theoretical understanding of it (Graneheim et al, 2017). This implies that the research moves from solid, concrete, and specific information to a general understanding of it. In the current study, Grade 9 examination questions were grouped into cognitive levels (themes). The questions were compared and interpreted until they could be narrowed down to fit into one of the descriptions of cognitive levels prescribed in CAPS. As a result, classifying mathematics questions into cognitive levels by teachers can be described.

I made a significant effort to ensure that the final analysis of the examinations provides a credible account of the data through intercoder reliability (ICR). ICR was used to enhance the quality, transparency, and reception (by a diverse audience) of my analysis of the school-based examinations. According to O' Connor and Joffe (2020), ICR involves the numerical measure of consensus among researchers performing the same analysis on the same data. In addition, O' Connor and Joffe (2020) mostly applied ICR within the thematic and qualitative content analysis and found that it improved their analysis. The current analysis was verified by a CAPS specialist, where, in addition to my analysis, I requested them to analyse the examination papers so that the quality of the dependability of this study could be enhanced.

3.8 QUALITY CRITERIA

To enact and demonstrate quality, the study followed in the footsteps of the most highly cited system of quality criteria for qualitative research. The four key concepts that are used to ensure quality in qualitative research are credibility, transferability, dependability, and conformability (Lincoln et al, 2011). I have explained each of these quality criteria in the next paragraphs guided by Threharne and Riggs (2014) and contextualised them to my study.

3.8.1 Credibility

Credibility is the quality of being trusted or believed, therefore, to enhance credibility in this study, triangulation of data was applied. This implies that the data were collected from different viewpoints, and from different sources so that the biases of the researcher could be eliminated as much as possible (Threharne & Riggs, 2014). To be precise, the data were collected from three different schools in the same educational circuit in Limpopo province, it is also assumed that the examination papers were developed at different times and by individuals with different viewpoints from each other.

3.8.2 Transferability

Transferability is related to the extent to which the findings of the research can be transferred to other contexts (Threharne & Riggs, 2014). Transferability was increased by working with documents that match the qualities described in the sampling criteria, and by providing a rich description of responses and interpretations of the artefacts

3.8.3 Dependability

According to Threharne and Riggs (2014), dependability is the consistency found in the research findings, it answers the question of whether similar findings would be reproduced if someone else undertook similar research. As such, a significant effort was made to ensure that the final analysis of the examinations provides a credible account of the data through intercoder reliability (ICR). ICR was used to enhance the quality, transparency, and reception (by a diverse audience) of my analysis of the school-based examinations. According to O' Connor and Joffe (2020), ICR involves the numerical measure of consensus among researchers performing the same analysis on the same data. In addition, O' Connor and Joffe (2020) mostly applied ICR within the thematic and qualitative content analysis and found that it improved their analysis. The current analysis was verified by a CAPS specialist, where, in addition to my analysis, I requested them to analyse the examination papers so that the quality of the dependability of this study could be enhanced.

3.8.4 Conformability

Conformability assesses the extent to which the findings of the research study are a product of the participants' viewpoints, motivations, interests, and perspectives (Threharne & Riggs, 2014). The data collected from the documents was the only data used to arrive at conclusions. Furthermore, all the raw data including the examination question papers with their memoranda were handed over to the University of Pretoria for record-keeping, however, the data collection instruments (rubrics) are attached as appendices to this current study.

3.9 ETHICAL CONSIDERATIONS

Christians (2011) claims that the acceptable way to conduct oneself is to maximize the happiness of others. Therefore, ethical behaviour is defined as possessing good character and acting in a way that demonstrates wisdom, honesty, courage, and bravery (Kitchener & Kitchener, 2009). The examination papers that formed a part of this study were treated as intrinsically valuable. This was to ensure that DBE schools, respective circuits, and districts understand the procedure of the research and that they are not going to be exploited or have their names tarnished. The examination papers were not in the public domain (they are the intellectual property of the schools) so there was a need to seek permission from the schools before analysing them. In addition, pseudonyms were used to conceal the names of schools that participated in the study. To further ensure ethical accountability I applied for ethical approval to collect data and ethical clearance after I collected data from the Ethics Committee of the University of Pretoria.

3.10 CONCLUSION

In this chapter, I presented methods guided by Saunders et al. (2019) research onion that I followed in addressing the research questions. Firstly, I adopted the interpretivist philosophy because I had to conduct the analysis of real examination-developed educators' teaching practice where multiple realities/interpretations were inherent. This philosophical choice was followed by the research approach, where I opted for the inductive research approach. Choosing the inductive approach leads to qualitative research methods (Sahay, 2016). Therefore, the study is qualitative, and the methodological choice formed part of the third layer of the research onion. The research strategy made up the fifth layer of the research onion, in this study the research strategy was the case study. As is the case with a research guided by the research onion the current study could have only one of two-time horizons (sixth layer of the research onion) a cross-sectional time horizon or a longitudinal time horizon (Saunders et al. 2019).

The current study has a cross-sectional time horizon. The last layer of the research onion that I addressed was the techniques and procedures. Firstly, I identified the research site and sampling methods. The data (examination papers) were all collected from three schools in the same educational circuit in Limpopo province. The sampling methods that I used are convenient sampling and purposive sampling. Secondly, I used document analysis as the then main method to collect data and for analysis.

Lastly, guided by Vaismoradi et al. (2013) I adopted qualitative content analysis to analyse the data that I collected. To enact and demonstrate quality, in the study I followed in the footsteps of the most highly cited system of quality criteria for qualitative research. The four key concepts that are used to ensure quality in qualitative research are credibility, transferability, dependability, and conformability (Lincoln et al, 2011).

The chapter concludes with ethical considerations, permission was sought from schools to use their examination in the study. In addition, pseudonyms were used to conceal the names of schools. The measures taken to uphold ethical behaviour ensure that the schools do not get exploited or get their names tarnished.

CHAPTER FOUR: RESEARCH FINDINGS

4.1 INTRODUCTION

In this chapter, I present the findings of the current research study. The findings were mainly guided by the cognitive levels of questions as well as the scope of content prescribed in the CAPS for Grade 9 (DBE, 2011). Knowledge of the curriculum is part of the MKT knowledge domain that teachers need to respond to everyday teaching tasks, and for the most part, those tasks involve assessing learners. I collected data using two data collection instruments, namely rubrics in Appendix A and Appendix B. However, I converted each of the two rubrics into spreadsheets for the effective recording of data and convenience in the generation of graphical representations of the findings. Although the graphical representations of this study (the tables and graphs) appear to be quantitative, Vaismoradi, Turunen, and Bondas (2013) guide us that qualitative content analysis enjoins researchers to use percentages and graphical representations such as the ones in this current study without rendering them as quantitative data.

Moreover, a significant effort was made to ensure that the final analysis of the examinations provides a credible account of the data through intercoder reliability (ICR). ICR was discussed in chapter three, and it was used to enhance the quality, transparency, and acceptance (by a diverse audience) of my analysis of the school-based examinations. According to O' Connor and Joffe (2020), ICR involves the numerical measure of consensus among researchers performing the same analysis on the same data. The expertise of a CAPS specialist was sought in this regard.

4.2 COGNITIVE LEVELS OF QUESTIONS IN THE EXAMINATIONS OF THE THREE SCHOOLS

In this section, I present the findings regarding the cognitive levels of questions from the three mathematics Grade 9 examination question papers. As discussed earlier in chapter two, the DBE classifies items in assessment according to four cognitive levels namely Knowledge, Routine procedures, Complex procedures, and Problem-solving. The knowledge level, which can be thought of as having the simplest set of questions, requires; straight recall, use of mathematical facts, identification and direct use of formulas and appropriate use of mathematics vocabulary (CAPS, 2011). In addition, the type of questions within the knowledge domain should be approximately have a weighing of 25%. Inconsistent with the knowledge domain, for routine procedure questions the learners are expected to perform well-known procedures, calculations that may involve many steps, and the use of formulas that may require a change of the subject. The mathematics questions are generally like activities that learners encounter in class, and at 45% weighting, the routine procedures have the highest weighting of all four cognitive levels. The complex procedure questions consist of questions that require learners to demonstrate high-order reasoning, there is no obvious way to find the solution to problems, they require conceptual understanding and elementary axioms need to be investigated so they can be generalized into proofs by learners. In assessment, the weight for these questions should be 20%.

Lastly, problem-solving questions are questions of the highest level of cognitive demand with 15% weighting in the assessment, usually unseen, non-routine, with high-order understanding and processes involved and may require the ability to break the problem down into parts that make it up. The qualitative descriptors associated with each cognitive level assisted me to categorize the questions accordingly. Guidance in the curriculum policy in terms of the threshold of the approximated weighting for each cognitive level is a two-percentile point threshold (DBE, 2019). In other words, for instance, if the actual weighting of knowledge questions in the examination is two per cent more or less than 25% prescribed in the curriculum, then I regarded it is being acceptable.

The data collected in this section responded to the first and the second sub-questions, viz. To what extent do the questions in Grade 9 mathematics examinations address the cognitive levels of questions prescribed in the CAPS? and how are the questions in the Grade 9 mathematics examinations spread in relation to the percentile weighting prescribed in CAPS?

4.2.1 Findings regarding the cognitive levels of questions in the examination from School A

The examination from School A comprised seven questions with a total mark of ninety-eight (98), although the examiners indicated that the total mark was one hundred (100). To determine the weighting of each cognitive level, I converted the total mark of each cognitive level into a percentile mark to be in line with the weighting used in CAPS. In fact, it should be noted that the weighting is determined by the total marks and not the number of questions associated with a cognitive level. The findings revealed that overall, all the cognitive levels were represented in the examination from School A. However, the cognitive levels across the seven questions were spread out in a way that lacked any obvious organization. An example of my categorization of one of the questions into cognitive levels in the examination from School A is that of a particular 5.1.1 question (see figure 4.1).

QUESTION 5

5.1 GIVEN: $14p^4 - 2p^3 + 8p - 6$

5.1.1 How many terms does the expression have? (1)

Figure 4.1: Example of question in the examination from school A

I categorised question 5.1.1 as a knowledge level question because it appears that in answering the question Grade 9 learners straightforwardly need to recall that they must count the parts of the expression that are separated by the addition (+) and subtraction (-) signs. In so doing they will exhibit the descriptors of the knowledge level such as straight recall and appropriate use of mathematics vocabulary. My categorisation of the rest of the questions in the examination from school A is summarised in Table 4.1.

Table 4.1: Expected cognitive levels vs. actual cognitive levels of questions (examination from School A)

COGNITIVE LEVELS	QUESTIONS IN THE EXAMINATION							TOTAL MARKS	ACTUAL WEIGHTING (%)	CAPS WEIGHTING (%)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7			
Knowledge	8	0	2	3	1	0	6	20	20.4%	25 %
Routine procedures	8	8	10	6	8	8	11	59	60.2%	45%
Complex procedures	0	3	4	0	6	0	3	16	26.3%	20%
Problem-solving	0	0	0	0	0	3	0	3	3.1%	10%
TOTAL	**16**	**11**	**16**	**9**	**15**	**11**	**20**	**98**	**100%**	**100%**

Questions that I categorized as cognitive level 1 (knowledge questions) featured in questions 1, 3, 4, 5, and 7 of the examination, whereas routine procedure questions featured in all the questions in the examination. In the examination from School A, the proportion of marks for knowledge and routine procedure questions was twenty and fifty-nine which translates to 20.4 and 60.2% respectively. The percentage weighting of 60,2 is relatively high as compared to the stipulated 45% in CAPS. Complex procedures were featured in questions 2, 3, 5 and 7 while problem-solving questions were featured in question 6 only with weightings 26,3% and 3.1% respectively. The 3.1% for problem solving is also seemingly much lower than the prescribed 10% for the cognitive level. In terms of percentile weighting, the cognitive levels that were underrepresented in the examination include knowledge questions, complex procedures questions, and problem-solving questions. Routine procedure questions had a high representation that comprised more than the sum of the percentile weightings of the other three cognitive levels. To have a better understanding of the distribution of questions according to the cognitive levels, I have compared the actual percentile weighting in the examination with the percentile weighting prescribed in CAPS (Figure 4.2).

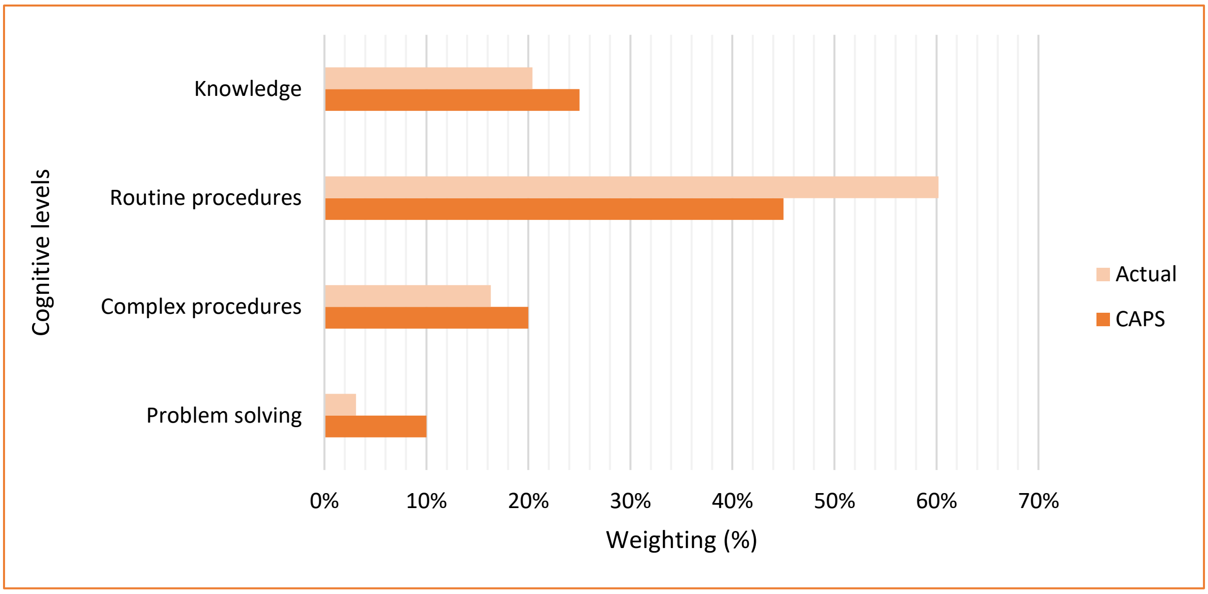


Figure 4.2: Comparison of the weighting of cognitive levels - examination from School A

Knowledge questions were slightly underrepresented with an actual weighting of 20, 4% as opposed to the prescribed weighting of 25%. Routine procedure questions featured in all seven questions in the examination. Therefore, it is not surprising that routine procedures had a considerably high representation in the examination of 60,2% much higher than the expected 45%. Evidently, the extremely high proportion of actual weighting for routine procedures has compromised the other three cognitive levels in terms of their actual weighting which are significantly lower than the prescribed weighting in CAPS.

4.2.2 Cognitive levels of questions in the examination from School B

Unlike the examination in School A, the examination in School B comprised eight questions and had a total mark of hundred (100). This allowed the mark that represented each cognitive level to be used as the actual weighting of the cognitive level. Similar to the findings in school A, all cognitive levels were represented in the examination from School B. A more striking similarity that I found was that routine procedure questions were featured across all eight questions in the examination and had the highest representation of all the cognitive levels. I used question 7 (a) to illustrate my categorization of questions into cognitive levels in the examination from school B (see Figure 4.3).

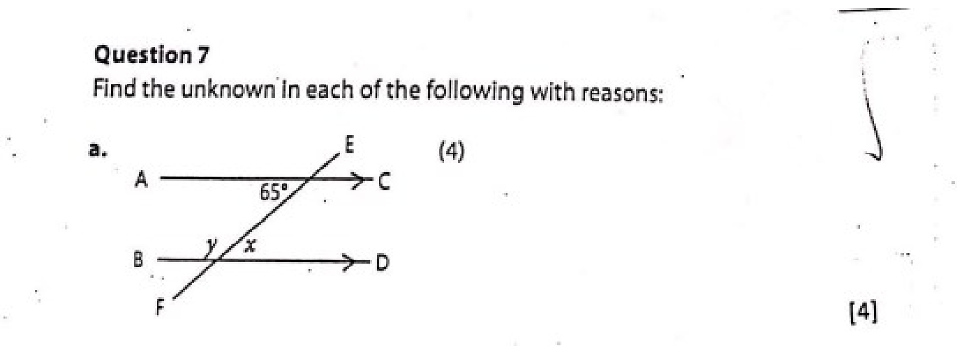


Figure 4.3: Example of question in the examination from school B

In question 7 (a) Grade 9 learners were asked to find the unknown (angles) from the given sketch. This question necessitated those learners perform well-known procedures coupled with simple applications and calculations which might involve many steps. For example, learners had to have knowledge of the fact that alternating angles are equal, and that the angles on a straight line add up to 180˚. For these reasons, the question in 7 (a) was categorized as a routine procedures-level question. A more comprehensive overview of my categorization of questions into cognitive levels in the examination from School B is depicted below (see Table 4.2).

Table 4.2: Expected cognitive levels vs. actual cognitive levels of questions (examination from School B)

COGNITIVE LEVELS	QUESTIONS IN THE EXAMINATION QUESTION PAPER								TOTAL MARKS:	ACTUAL WEIGHTING (%)	CAPS WEIGHTING (%)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8			
Knowledge	6	0	0	0	10	0	0	3	19	19%	25%
Routine procedures	13	9	4	8	9	9	4	1	57	57%	45%
Complex procedures	3	3	3	8	3	0	0	0	20	20%	20%
Problem-solving	0	0	4	0	0	0	0	0	4	4%	10%
TOTAL:	**22**	**12**	**11**	**16**	**22**	**9**	**4**	**4**	**100**	**100%**	**100%**

Knowledge questions in the examination from School B featured in questions 1, 5, and 8 with total marks of nineteen (19) which implied a 19% actual weighting in the examination. This is a slight discrepancy of 6% from the prescribed weighting of 25% in CAPS. The routine procedure questions enjoyed a high representation by being featured in all the questions of the examination with a combined total mark of fifty-seven (57) or 57%. Complex procedures were featured in questions 1, 2, 3, 4 and 5 with 20 marks which translated to 20%. Problem-solving questions featured in one of the questions (question 3), they had a mark of 4 which translates to 4%. To better understand the cognitive levels findings of the examination in school B, the actual weighting of the cognitive levels was compared to the percentile weighting prescribed in CAPS (Figure 4.4).

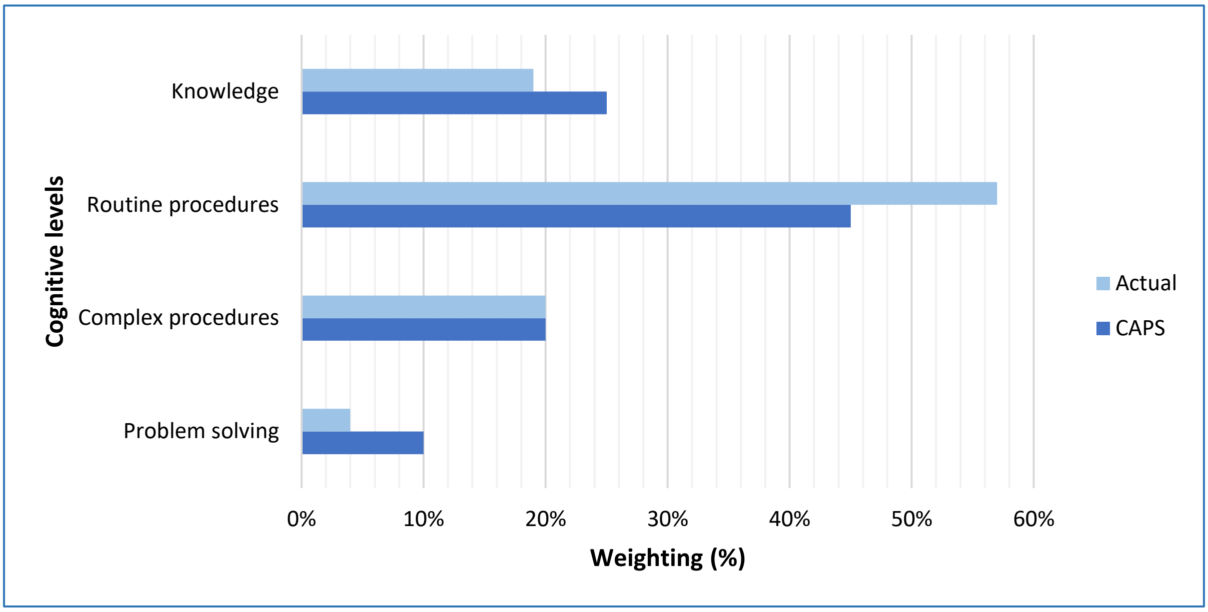


Figure 4.4: Comparison of the weighting of cognitive levels - examination from School B

Knowledge questions that are prescribed a 25% representation in an examination were underrepresented with 19%. As compared with the actual weighting of 45% in CAPS, the findings revealed a significant excess score of 12% in routine procedures in the examination. Notably, complex procedures had an accurate representation of 20% across five of the questions it was featured in. Regardless, problem-solving questions were severely underrepresented in the examination, the questions that fit the description of this cognitive level featured in only one question, i.e. Q3 with four (4) marks that meant a 4% representation out of a possible prescribed 10%. Evidently, a significantly high actual weighting taken up by routine procedures questions compared to what is prescribed in CAPS impacted negatively on the actual weighting of knowledge and problem-solving questions.

4.2.3 Cognitive levels of questions in the examination from School C

The examination from School C had a total of nine questions and a total mark of hundred (100). This, therefore, implied that the total marks of the questions categorized in each cognitive level also constituted a percentile weighting. As with the examinations from the other two schools, the examination from School C catered for all cognitive levels. Questions that I classified as knowledge questions featured across questions 1, 2, 5, 7 and 8 with and overall of 13 marks or 13%. Questions classified as routine procedure questions featured across all the questions except in question 7. Flowing from the pattern with the other two examinations, routine procedures had the highest mark of fifty-seven (57). Complex procedures were featured in all the questions except for questions 6 and 7 while problem-solving questions were featured in two of the questions with a total of eight marks. I used two questions from the examination from School C to illustrate how I categorised the questions in this into cognitive levels. First, for the complex procedures level questions, I selected question 8.4, and then for the problems-solving level questions I used question 5.2.2 see Figure 4.5 and Figure 4.6 below.

5.2	Simplify each of the following expressions:-		
	5.2.1	$3m - n + 6n - 5m$	(2)
	5.2.2	$\frac{b^3 + 18b^2 - 15b}{3b}$	(3)

Figure 4.5: Example of question in the examination from school C

8.4	ABCD is a parallelogram. Calculate the size of $\hat{B}$.	(4)

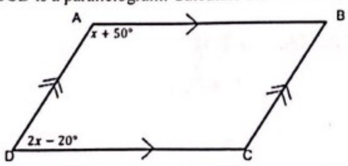


Figure 4.6: Example of question in the examination from school B

In question 5.2.2 learners had to simplify a fraction that consisted of a trinomial (numerator) and a monomial (denominator). I categorised the question as a complex procedures level question because it requires complex calculations and/or high-order reasoning. In addition, there is no obvious way of getting to the answer as learners have to first factorise the numerator and then apply the concept of division, therefore, a connection between different representations has to be made. Hence, the categorisation of question 5.2.2 as complex procedures. I further categorised question 8.4 as a problem-solving level question because it appears to be a never seen before question (from a Grade learner point of view), a non-routine problem (that is not necessarily difficult).

The full categorisation of questions into cognitive levels from examination from School C is summarised in the table below (see Table 4.3).

Table 4.3: Expected cognitive levels vs. actual cognitive levels of questions (examination from School C)

COGNITIVE LEVELS	QUESTIONS IN THE EXAMINATION QUESTION PAPER									TOTAL MARKS	CAPS WEIGHTING (%)	ACTUAL WEIGHTING (%)
	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9			
Knowledge	3	2	0	0	2	0	5	1	0	13	25%	13%
Routine procedures	5	2	6	6	11	6	0	11	10	57	45%	57%
Complex procedures	2	2	2	3	7	0	0	3	3	22	20%	22%
Problem-solving	0	0	0	0	4	0	0	4	0	8	10%	8%
TOTAL	**10**	**6**	**8**	**9**	**24**	**6**	**5**	**19**	**13**	**100**	**100%**	**100%**

In line with the other two examinations routine procedures had a high representation of 57%. The implication of this is that the other cognitive levels (knowledge and problem-solving questions) were underrepresented. The actual weighting was compared to the prescribed weighting in CAPS to better understand how the cognitive levels were spread in the examination in School C (Figure 4.7).

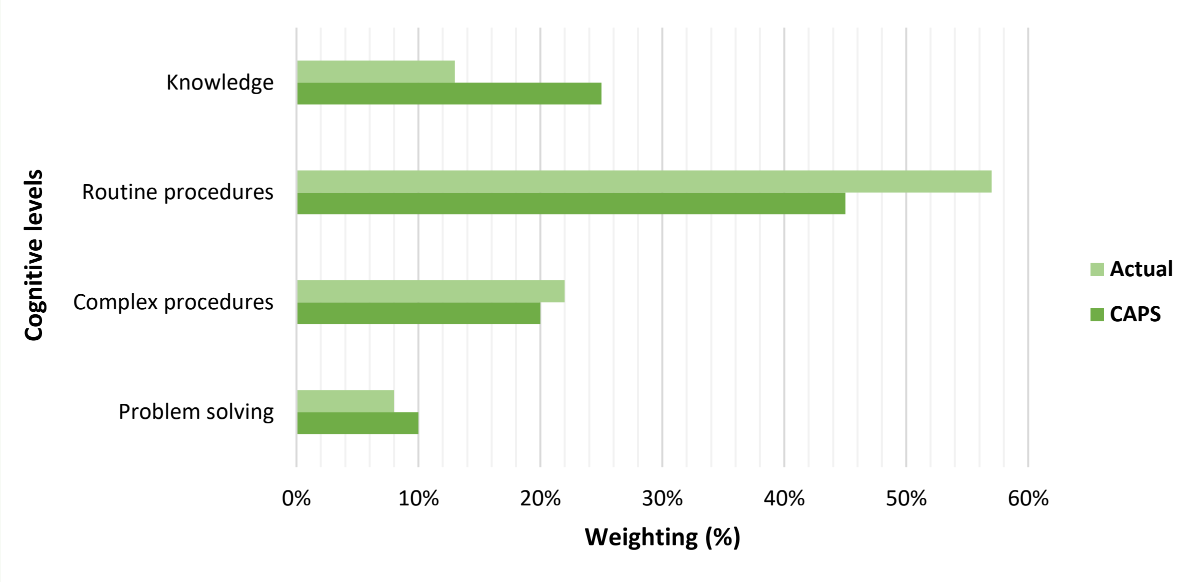


Figure 4.7: Comparison of the weighting of cognitive levels - examination from School C

Knowledge questions were largely underrepresented as compared with the other cognitive levels within the examination with an actual weighting of 13%, close to half of the expected weight of 25%. Complex procedures had a representation of 22% just slightly higher than the expected 20%. Problem-solving questions had a much higher representation in the examination from School C than in the other two examinations with a representation of 8% just 2% away from the expected 10%. Concerning the two percentile margins recommended in CAPS, the examination from School C is more aligned with the prescribed weightings in CAPS in terms of complex procedures and problem-solving questions than the other two examinations in Schools A and B. The over-representation of routine procedure questions had an impact on knowledge questions being underrepresented.

4.3 FINDINGS ON THE SCOPE OF CONTENT

In this section, I present the findings for the scope of the content of the three mathematics Grade 9 examination question papers from the three schools in the same educational circuit in Limpopo province. By the scope of content, I refer to the five main content areas in the Senior Phase (Grades 7-9) that each contributes towards the acquisition of specific skills by the learners. The five content areas in mathematics include (a) Numbers, operations and relationships; (b) Patterns, functions and algebra; (c) Space and Shape (Geometry); (d) Measurements; and (e) Data-handling (DBE, 2011). For Grade 9, the content areas are allocated the weightings of 15%, 35%, 30%, 10% and 10% respectively. As stated in CAPS (DBE, 2011), "the weighting of mathematics content areas serves two primary purposes: guidance on the time needed to adequately address the content within each content area, [and] guidance on the spread of content in the examination (especially end-of-year summative assessment)" (p. 11). The collection of data, therefore, whose findings are presented here was guided by the weighting of content espoused by the Department of Basic Education. Again, a two-percentile threshold is acceptable as compliance with curriculum policy.

To guide my analysis of the content areas, I used the descriptors listed in CAPS that specify the topics that are classified under a particular content area for a specific grade. For example, one of the topics that are grouped under measurement is the Theorem of Pythagoras (Table 4.4).

Table 4.4: Example of specification of content (phase overview) Measurement (DBE, 2011)

Topics	Grade 7	Grade 8	Grade 9
The Theorem of Pythagoras		**Develop and use the Theorem of Pythagoras** • Investigate the relationship between the lengths of the sides of a right-angled triangle to develop the Theorem of Pythagoras • Determine whether a triangle is a right-angled triangle or not if the length of the three sides of the triangle is known • Use the Theorem of Pythagoras to calculate a missing length in a right-angled triangle, leaving irrational answers in surd form	**Solve problems using the Theorem of Pythagoras** • Use the Theorem of Pythagoras to solve problems involving unknown lengths in geometric figures that contain right-angled triangles

Table 4.4 shows that the theorem of Pythagoras is not part of the content to be taught in Grade 7. However, it is a part of the content to be taught in Grades 8 and 9. Furthermore, in Grade 8 learners' knowledge of the theorem of Pythagoras is developed by investigating the relationship between the lengths of the sides of a right-angled triangle. In contrast, learners use the theorem of Pythagoras to solve problems involving unknown lengths in geometric figures that contain -right-angled triangles in Grade 9. It is my argument that it is a lot easier for people who do not teach mathematics and for examiners that do not have adequate knowledge of the curriculum to classify questions that contain the theorem of Pythagoras as space and shape (Geometry) questions. It is also quite possible to pitch the questions involving the theorem of Pythagoras at a lower level than is required for Grade 9.

This implies that if questions in Grade 9 involve the description of Grade 8 questions, then the questions are pitched at a lower level for them. In deliberations with the CAPS expert for ICR, it was agreed that some of the questions in the examination that were collected were pitched at a lower level than is required for Grade 9. Some of the questions were for Grades 7 and 8 mathematics assessments. Knowledge of content and curriculum is part of the MKT framework that teachers need to organise teaching and learning, for the most part, this knowledge involves assessing learners too. The data was collected using a rubric whose qualitative descriptors are drawn from the curriculum and converted to a spreadsheet (see Appendix B).

Furthermore, the findings of the data pertaining to the scope of content when setting the examination are responding to the third and fourth sub-questions of the study, viz. To what extent do the questions in Grade 9 mathematics examinations address the content areas prescribed in CAPS? And to what extent do the questions in the Grade 9 mathematics examinations assess the scope of content as specified for Grade 9?

4.3.1 Scope of content in the examination from School A

The examination from School A was written out of a total of ninety-eight (98) marks and had a total of seven questions as stated earlier in this chapter. Once more to determine the weighting of each content area, I converted the total mark of each content area into a percentile mark to be in line with the weighting used in CAPS. For example, if content area 1 numbers, operations, and relationships (NOR) was represented by three of the questions in the examination, the total mark for each question where the content area was represented was converted to a percentile mark and used as an indication of the actual weighting as a percentage of the content area. The actual mark would then be compared to the prescribed weighting in CAPS. Furthermore, the examination in School A failed to present all the mathematics content areas specified for Grade 9 in CAPS (see Table 4.5).

Table 4.5: Scope of content according to content areas (examination from School A)

CONTENT AREAS	QUESTIONS IN THE EXAMINATION QUESTION PAPER							TOTAL MARKS:	ACTUAL WEIGHTING (%)	CAPS WEIGHTING (%)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7			
NOR	16	11						27	27.5%	15%
PFA			16	9	15	11		51	52%	35%
Geometry							20	20	20%	30%
M								0	0%	10%
DH								0	0%	10%
TOTAL:	16	11	16	9	15	11	20	98	100%	100%

Numbers, operations, and relationships (NOR) are featured in two of the questions (questions 1 and 2) in the examination. The total mark for the two questions that represented NOR was twenty-seven (27). This implies that the proportion of marks for questions categorised as NOR in the examination from School A had a representation of 27.5%. Patterns, functions, and relationships (PFA) were featured in the greatest number of questions (questions 3, 4, 5, and 6) in the examination. Thus, PFA had the highest mark representation of fifty-one (51). Thus, a 52% representation of the content area. Of the content areas that were represented in the examination on School A, geometry was the least represented in one question (question 7) and with 20 marks. Hence, geometry had a 20% presence in the examination. Measurements (M) and Data-handling (DH) were not featured in the examination in School A. as a result, they both had zero (0) marks and a 0% representation in the examination.

Figure 4.8 sheds light on the comparison I made of the actual weighting against the expected weighting of the content areas in CAPS.

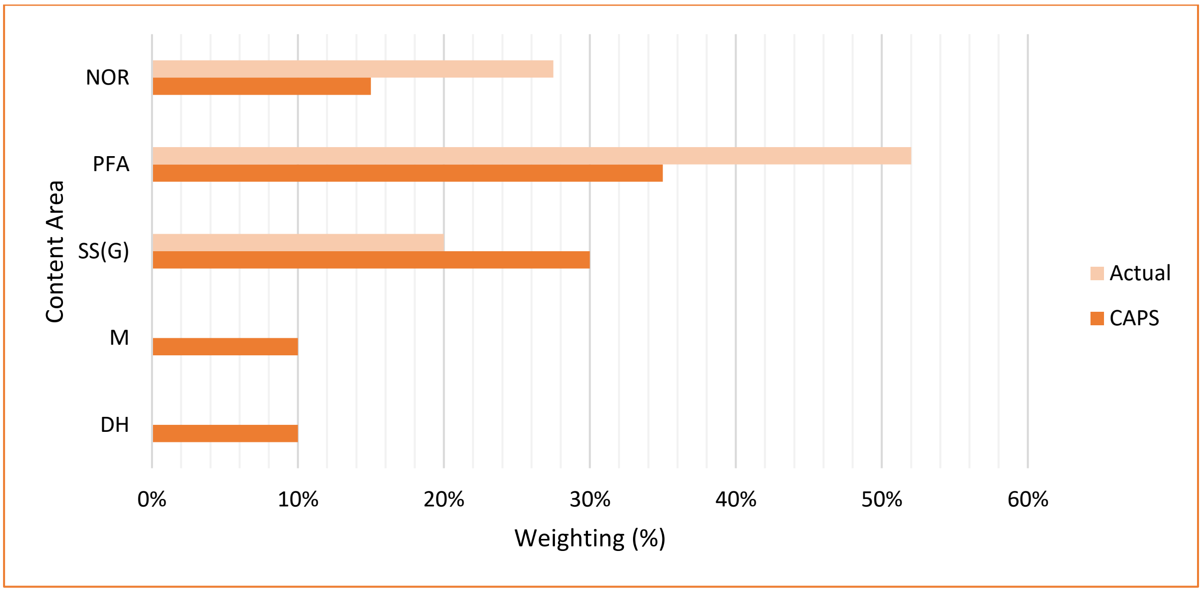


Figure 4.8: Comparison of the weighting of the scope of content - examination from School A

As illustrated by Figure 4.4, NOR and PFA were over-represented in the examination in School A. The 27% representation of NOR was much higher than the prescribed 20% for the content area. In the same breath, PFA also had a significantly high representation of 52% as opposed to the expected 35% representation in CAPS. Although Geometry was represented by 20% in the examination, this figure is lower than the expected 30%. Hence, Geometry was underrepresented. Even more so, Measurements and Data-handling were severely underrepresented in the examination in School A. The two content did not enjoy a feature in the examination with each of them receiving a 0% representation. The expected weightings of the two are 10% each.

4.3.2 Scope of content in the examination from School B

As asserted earlier, the scope of the content of the examination from School B was presented across eight questions. The examination was out of a hundred (100). The marks that represented each content area could be used as the actual representation of the content area as was the case with cognitive levels findings. Furthermore, not all content areas were featured in the examination from School B. Only four of the content areas were assessed NOR, PFA, Geometry, and measurements (M) (see Table 4.6).

Table 4.6: Scope of content according to content areas (examination from School B)

CONTENT AREAS	QUESTIONS IN THE EXAMINATION QUESTION PAPER								TOTAL MARKS	ACTUAL WEIGHTING (%)	CAPS WEIGHTING (%)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8			
NOR	22								22	22%	15%
PFA		12	11	16	15	4			58	58%	35%
Geometry						5	4	4	13	13%	30%
M					7				7	7%	10%
DH									0	0%	10%
TOTAL:	**22**	**12**	**11**	**16**	**22**	**9**	**4**	**4**	**100**	**100%**	**100%**

NOR were tested in the first question with a total of twenty-two (22) marks which constituted 22% in percentile weighting. Next, PFA was examined across the greatest number of questions in the paper, questions 2, 3, 4, 5, and 6. The total for the five questions was fifty-eight (58). Therefore, 58% of the questions in the paper were for PFA. Geometry was a part across questions 6, 7 and 8 with combined marks of thirteen (13). Thus, a representation of 13%. Measurement questions featured only in question 5, they had a mark of seven (7). In addition, it was integrated within question 5 that was examining another content area (PFA). Data-handling questions were not featured in the examination.

Moreover, there was a mismatch among the comparisons of the actual weighting of content areas and the prescribed weighting in CAPS for NOR, PFA, and Geometry (Figure 4.9).

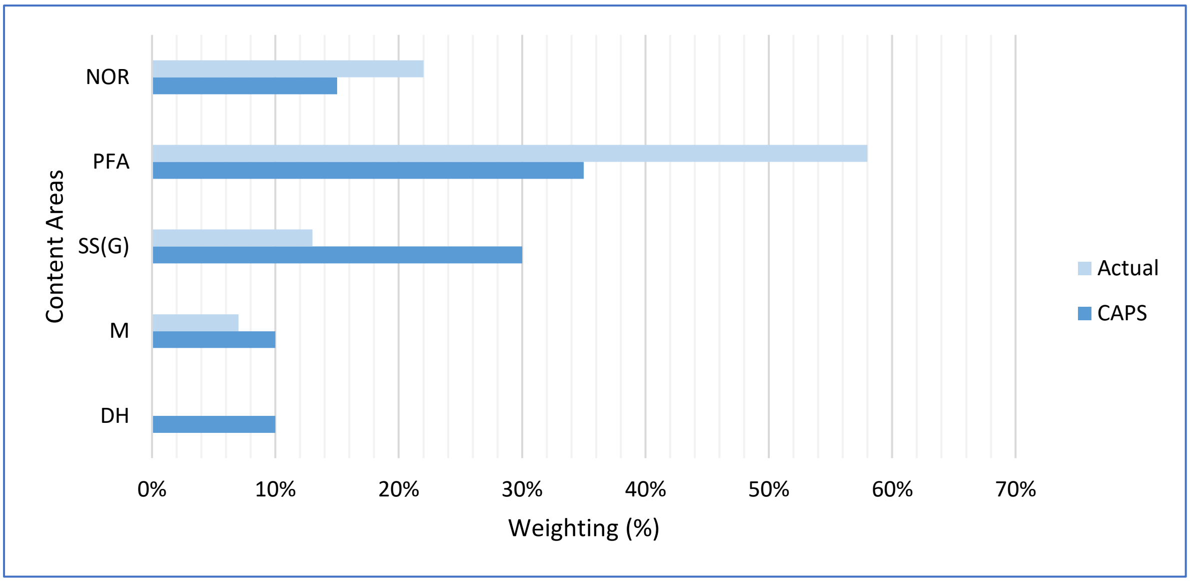


Figure 4.9: Comparison of weighting of scope of content - examination from School B

NOR surpassed the prescribed 15% by 7%. PFA had the greatest deviation exceeding its prescribed weighting by 23%. Geometry and measurement questions were underrepresented. Geometry had a shortfall of 17% while the expected weighting is 30%. Although Measurement questions were more aligned with the expected weighting of 10% with their 7%, this representation falls outside the two-percentile deviation recommended in CAPS. The main topic that was tested for measurement was area, perimeter, and volume. Flowing from the findings in School A Data-handling questions were not represented in the examination; thus, a comparison could not be made. The underrepresentation of Data-handling can be attributed to the high representation of PFA and NOR.

4.3.3 Scope of content in the examination from School C

The examination from School C had a total of nine questions, Four content areas were featured in the examination (NOR, PFA, Geometry, and data-handling). Three of the questions represented NOR that is questions 1, 2, and 9 (see table 4.7).

Table 4.7: Scope of content according to content areas (examination from School C)

CONTENT AREAS	QUESTIONS IN THE EXAMINATION QUESTION PAPER									TOTAL MARKS	ACTUAL WEIGHTING (%)	CAPS WEIGHTING (%)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9			
NOR	4	6							13	23	23%	15%
PFA	2		8	9	24					43	43%	35%
Geometry	3					6	5	19		33	33%	30%
M	1									1	1%	10%
DH										0	0%	10%
TOTAL	**10**	**6**	**8**	**9**	**24**	**6**	**5**	**19**	**13**	**100**	**100%**	**100%**

The questions that I categorized as NOR had a total of twenty-three (23) marks and a 23% representation of the content area. As with the other examinations from the other two schools, PFA, as well as Geometry, were represented. PFA was represented across four questions (questions 1, 2, 3, and 5) and Geometry was presented across four questions (questions 1, 6, 7 and 8). PFA had forty-three (43) marks, while Geometry had thirty-three (33) marks. Measurement questions and data-handling questions were severely underrepresented. Measurement questions featured in the first question with one (1) mark. Data-handling questions were not featured in the examination from School C. I made comparisons of the actual and prescribed weightings to get a better understanding of the extent of alignment of the content areas with the curriculum (CAPS) (Figure 4.10).

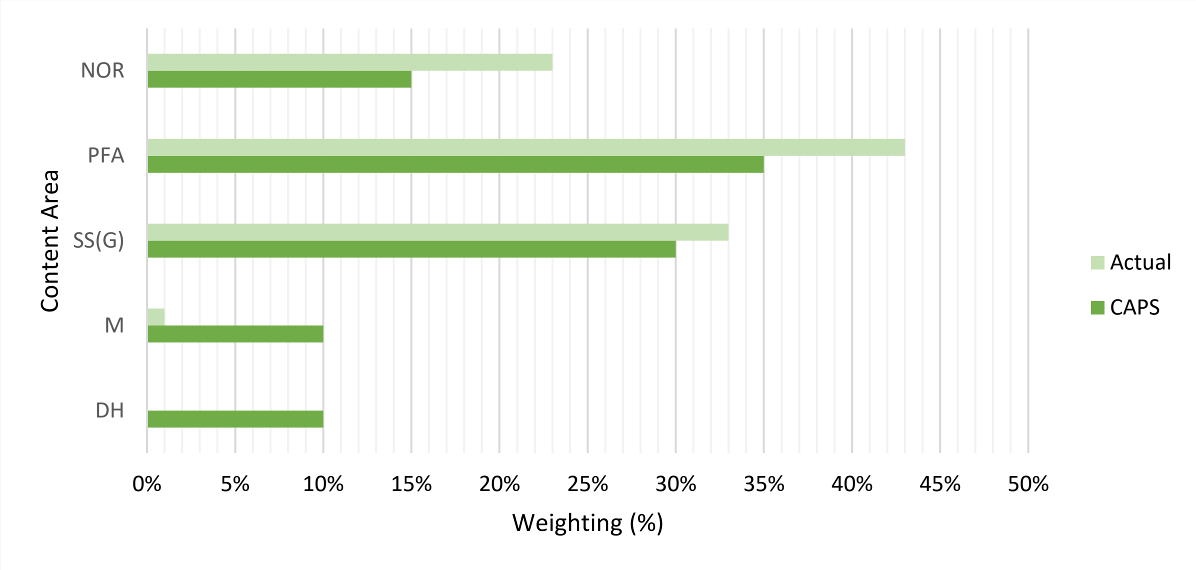


Figure 4.10: Comparison of the weighting of the scope of content - examination from School C

The comparison revealed that NOR, PFA, and Geometry were over-represented in the examination. The expected weighting for NOR is 15%, the examination exceeded this percentile weighting by 8%. PFA also had an excess score of 8%, contrary to the expected weighting of 35%. Unlike the examinations in Schools A and B, the examination in School C had a high representation of Geometry questions. The questions accounted for 33% of the content areas while the expected weighting is 30%.

As was the case with the other two examinations, measurement (M) as well as data-handling (DH) were underrepresented. The latter had no presence in the examination. Presumably, this is due to the much higher representations of NOR, PFA, and Geometry. However, measurement questions as was the case with the examination from School B were slightly represented in question one for one (1) mark and thus a 1% representation. In the same breath, the high marks allocated for the other three content areas are responsible for this major shortage of measurement questions.

4.4. CONCLUSION

This chapter aimed to present the findings of this study. The findings were mainly guided by the cognitive levels of questions as well as the scope of content prescribed for Grade 9 mathematics in CAPS. The weightings were determined by the total marks in the examinations and not by the total marks associated with a particular cognitive level or content area. Furthermore, a comparison between and across the actual weightings and the prescribed weightings (in CAPS) was made.

The cognitive levels findings revealed that the examinations in Schools A, B, and C were able to feature all the cognitive levels prescribed in CAPS. However, the examinations failed to accurately interpolate questions to match the correct/expected weightings for each cognitive level. Despite the two-percentile deviation for compliance recommended in CAPS, the actual weightings of the cognitive levels were quite different from the expected weightings. This difference in the weightings can be attributed to the over-the-top representation of knowledge questions and routine procedure questions. Complex procedures as well as problem-solving questions were mostly underrepresented. This underrepresentation is also evident in the number of questions that featured these levels. The comparisons of the actual and expected weightings also shed light on a great deal of discrepancy among and across the cognitive levels.

The scope of content findings revealed that the examinations in Schools A, B, and C did not cover the full scope of the examination prescribed in CAPS. In other words, the five key content areas for the senior phase in mathematics were not fully featured in the examinations. Data-handling questions were not featured in any of the examinations. Measurement questions were largely underrepresented, while geometry questions could be said to have been fairly represented, although also not complying with the two-percentile deviation asserted in CAPS. PFA had the highest representation in all the examinations followed by NOR. The comparisons of the actual weightings and the expected weightings illustrated that too much emphasis put on PFA by the examiners results in the content areas not being featured in the examination.

Considering the cognitive levels findings as well as the scope of content findings, the chapter concludes that there is a mismatch between the school examinations and what is prescribed in CAPS.

CHAPTER FIVE: DISCUSSIONS, RECOMMENDATIONS, AND CONCLUSION

5.1 INTRODUCTION

In chapter four I presented the findings of my study. In this current chapter, I discuss the implications of the findings relating to the cognitive levels as they pertain to sub-research questions one and two, and the scope of content as it pertains to sub-research questions three and four, on mathematics teaching and learning. I also reflect on the affordances of the theoretical framework as a glue that bound the different aspects of the study together. Furthermore, I outlined the limitations that may have been a hindrance to my study, and make recommendations for examiners, policy makers and researchers. The chapter ends with conclusions that also answer the primary research question of this study: What is the extent of alignment between Grade 9 mathematics summative assessment and the prescripts of CAPS?

5.2 COGNITIVE LEVELS OF QUESTIONS IN THE EXAMINATIONS

In this section, I discuss the findings about whether the questions in the examinations from the three schools cover all the cognitive levels; and, how these questions are spread according to the percentile weighting prescribed in the CAPS. The two constructs, namely, coverage of cognitive levels and their spread according to percentile weighting are the focus areas of sub-research question one and sub-research question two respectively. The two sub-research questions are: Do the questions in Grade 9 mathematics examinations address the cognitive levels of questions prescribed in the CAPS? and, How are the questions in the Grade 9 mathematics examinations spread concerning the percentile weighting prescribed in CAPS? The discussions under the current heading (§5.2) were approached in an integrated manner in that they simultaneously respond to the first and second sub-questions.

5.2.1 Summary of the findings on cognitive levels

In the findings presented in chapter four, it was revealed that all the cognitive levels prescribed in CAPS were featured in the examinations of the three schools (A, B, and

C). This indicated that the examiners are aware of the prescripts of the curriculum (CAPS) regarding cognitive levels. In line with Shulman (1986) assertion that teachers need knowledge of content and curricular (KCC) for the PCK domain of MKT. However, findings regarding the spread of the questions in terms of the percentile weighting prescribed in CAPS revealed many discrepancies when compared with the actual weightings in the examinations. The only exception is questions that could be categorised as complex procedures. The actual weightings of the level of the complex procedure revealed the closest alignment with the prescribed weighting in CAPS.

In contrast, the level of the routine procedure had an excessively high representation across the examinations in the three schools. While the findings for the knowledge and problem-solving levels indicated substandard representations. Thus, the examinations did not cater for the full range of cognitive levels in terms of percentile weightings and learner abilities as prescribed in CAPS. To an extreme extent, how the examinations were presented was not appropriate for addressing the cognitive levels of Grade 9 learners. Contrary to Suurtman et al. (2016) assertion that assessment in mathematics must assess the appropriate complex nature of mathematics and the standards of the curriculum that guides teaching and learning, i.e., CAPS.

5.2.2 Knowledge level

The knowledge level can be thought of as having the simplest set of questions, it requires the use of straight recall, mathematical facts, identification and direct use of formulas, and the appropriate use of mathematical language (CAPS, 2011). According to Du Plooy and Long (2013), the knowledge level adds an important element of metacognition, thus, making learners aware of their learning and thinking processes. Moreover, failure to transition from the knowledge level to the level of the routine procedure, and the complex procedures and problem-solving levels is likely to result in a deteriorating mathematics competence at a higher phase of learning, such as the FET phase.

The examinations in schools A, B, and C did not accurately represent the knowledge level according to how it is prescribed in CAPS. This was the case despite the two-percentile threshold lower than the approximated CAPS prescript for compliance that was adopted in chapter four. This lack of alignment between the examinations and the curriculum could imply that examiners are not fully knowledgeable about the correct weighting for this cognitive level and thus about the curriculum (CAPS). This could further imply non-conformity with the nature of PCK, where it is argued by Ball et al. (2008) that successful mathematics teachers need knowledge of mathematics content and that of the curriculum (KCC) as part of their MKT. The ripple effect of the continuation of the presumed lack of knowledge is that teachers may not be in good standing to help learners learn mathematics and may not be ready to teach concepts and assess them.

A further implication is that of non-conformity with the guidelines provided for in the SAGM introduced by the CAPS (DBE, 2011) which clearly outlines the taxonomical differentiation of questions into cognitive levels that formed part of the research framework in this study. The outcomes that the curriculum is envisioned for become nullified, learners get discouraged to learn mathematics and teachers' professional development gets delayed. On the opposite end of the spectrum, one might stretch this lack of alignment to include examiner preference of cognitive levels to address in examinations. In other words, examiners seem not to prefer questions that address the knowledge cognitive level especially since it contains a set of questions that require straight recall, use of mathematical facts, identification and direct use of mathematical language according to CAPS (2011). These sets of questions might be perceived as mediocre by some examiners.

However, the knowledge questions are important for a smooth transition to the other three cognitive levels and for improving learner metacognition (Du Plooy & Long, 2013). This practice implies that learners get subjected to more questions that require higher cognitive levels such as the routine procedure level. This, puts much strain on their thinking as they must substantially think at a higher level, without having mastered the knowledge of basic mathematical concepts, therefore, hindering their learning. In fact, in a desperate attempt to improve learner proficiency in mathematics, especially in grades 7 to 9, knowledge questions are often undermined, yet they play a significant role as a foundation for what Kilpatrick (2001) referred to as strategic competency and adaptive reasoning.

In addition, this practice may favour gifted/successful learners because they might be in good standing to successfully answer questions that require them to think at a higher level. Given that most learners are not in the category of gifted learners, average learners (who are in majority) and struggling learners will be left out.

5.2.3 Routine procedures level

The routine procedures level is the second category of cognitive levels and consists of questions that require learners to perform familiar procedures, calculations that require many steps, and the use of formulas that may require them to change the formula (CAPS, 2011). Du Plooy and Long (2013) adopted Hiebert's and Carpenter's (1992) description of procedural knowledge as being characterised by having step-by-step use of actions that manipulate written mathematical symbols. This implies that procedural knowledge bestows in learners the ability to arrive at the answer to a mathematical problem. Regarding questions that required the use of procedural knowledge in the examinations, the level of the routine procedure had significantly high representations, the representations far exceeded the two-percentile weighting threshold by CAPS for compliance that was suggested in chapter four.

The over-representation of the level of the routine procedure suggests that mathematics classrooms are dominated by the teaching and learning of procedures. Not withholding the fact that competence in mathematics rests equally on the knowledge of procedures and conceptual grasp (discussed as complex procedures under the subsequent subsection) (Rittle-Johnson & Schneider, 2015). One gets the sense that too much emphasis on procedures defies the now most accepted perspective regarding the two types of knowledge; conceptual knowledge and procedural knowledge which is the iterative view/process (Rittle-Johnson & Schneider, 2015; Du Plooy & Long, 2013).

The iterative view/process supports gradual improvements in both types of knowledge and criticises emphasis on one of the types of mathematical knowledge over the other as in the examinations (Rittle-Johnson & Schneider, 2015; Du Plooy & Long, 2013). This is not surprising because mathematics classroom practice is dominated by the mastery of procedures (Source). This implies that due to their nature, routine procedure questions contain many steps, but learners are familiar with these steps from encounters in the classroom which is a further reflection of the nature of teaching mathematics that is dominated by procedures. However, this supports Veldhuis and

Heuvel-Panhuizen (2019) articulation of the importance of assessment being in line with what happens in the classroom, so teachers can better understand their learners. In other words, the questions that were categorised in this cognitive level were able to be put into practice successfully as far as the teachers are concerned. As such, it might have been a convenience for the examiners to have as many questions as possible of this nature in the examination. It was a convenience because the questions might be common as they were taught and solved in the classroom since the type of questions within the level of the routine procedure are generally like activities that learners have already encountered in class (DBE, 2011).

Furthermore, a lot more learners might be successful in obtaining better grades for the subject. However, there is a risk that learners will progress to the next grade without having grasped the full set of skills necessary to respond to questions that require other cognitive levels (the knowledge and problem-solving levels which were grossly underrepresented). Therefore, learners thinking is restricted, and they are not allowed to explore the full extent of mathematics content like as suggested by Machaba and Moloto (2021). The direct result is that the lower grades such as Grade 9 are unable to produce learners that are well equipped to participate in high stakes examinations such as the National Senior Certificate exams (NSC) in South Africa, and the international achievement assessments such as TIMSS.

5.2.4 Complex procedures level

Unlike the level of the routine procedure that requires learners to perform familiar procedures, the level of the complex procedure consists of questions that require high-order reasoning, there is no obvious route to solving the questions, and elementary axioms need to be investigated so they can be generalised into proofs, and they require conceptual understanding (DBE, 2011). Closely linked to the CAPS definition, Inayah, Septian and Suwarman (2020) talk about procedural fluency when talking about complex procedures in mathematics. Furthermore, according to Inayah, Septian, and Suwarman (2020) procedural fluency is strongly linked to an understanding of mathematical concepts and problem-solving. These (mastery of concepts and problem-solving) are important skills that need to be mastered by learners. Hence, Du Plooy and Long (2013) refer to the knowledge needed for complex procedures level as “conceptual grasp”. According to Du Plooy and Long

(2013), conceptual grasp refers to a group of interrelated ideas that need to be combined to form one big idea, which is conceptualised as one concept, however, this concept is big enough to be split into different sub-concepts.

The complex procedures level did not have a clear trend of over-representation or the opposite. In fact, the complex procedures level was the only cognitive level that had the closest alignment with the weightings prescribed in CAPS. Thus, the complex nature of mathematics was exhibited in the examinations. In compliance with Usikin (2012) description of mathematics as a complex subject which requires detailed processes of teaching and learning, and multifaceted understandings of mathematics portrayals, concepts, application of operations, and understanding of procedures. Moreover, the close alignment of the complex procedure level with CAPS implies a case of examiners being aware of the prescripts of CAPS. Thus, in consensus with Ball et al. (2008) assertion that teachers need to know the subject beyond factual and procedural aspects. The complex procedures level was accurately represented in the examination in School B.

Furthermore, the examination in School C complied with the CAPS two-percentile threshold for compliance suggested in chapter four. Although it was underrepresented in the examination in School A, the underrepresentation was not by a high margin, showing a four-percentile difference between the actual weighting and the expected weighting. This further conveys the impression that teaching, learning and assessment activities that bear on the conceptual grasp of mathematical ideas were considered crucial for mathematics progression by examiners. Indeed, mathematics assessments must be created in such a way that they promote the development of conceptual grasp in addition to the straight recall of mathematics knowledge and knowledge of procedures (Du Plooy & Long, 2013). This insinuates that learners were subjected to questions that may require high-order reasoning and conceptual grasp. Thus, reducing the chances of struggling with more difficult questions as they transition to higher grades.

While adherence to CAPS prescripts is commendable, insufficient exposure to knowledge questions in the assessment, which, arguably, could be the reflection on teaching and learning, could be a hindrance towards the successful achievement of questions at the complex procedure level.

5.2.5 Problem-solving level

The problem-solving level is the last category of cognitive levels. The type of questions that constitute the problem-solving level includes those that have never been seen before, are non-routine, that require high-order processes and understanding, and may require learners to break problems down into smaller simpler parts (CAPS, 2011). Consequently, a deep conceptual understanding is required for questions of the problem-solving level. One gets the sense that the problem-solving level must address the very nature of mathematics - to solve problems (DBE, 2011). Smith (2016) believes that learning to solve problems is the core principle for studying mathematics. Indeed, one of the general aims of the CAPS is to produce learners who can recognise and respond to contexts that require ‘problem-solving’ (CAPS, 2011).

However, the problem-solving level was the most underrepresented in all the examinations from the three schools. This is despite the problem-solving level questions complying with the two-percentile threshold that CAPS set for compliance (suggested in chapter four) in the examination from School C. The other two examinations from Schools A and B revealed an acute underrepresentation of the problem-solving level. Perhaps the gross under-representation is because CAPS itself is not a problem based rather content-driven. This is true since the problem-solving level is allocated the lowest percentile weighting (10%) of all the cognitive levels. This is despite DBE's (2011) additional acknowledgement that problem-solving is the core principle of mathematics by denoting that “the mathematics subject is a language that makes use of symbols and notations that help enhance ’problem-solving’, [and] learners should be able to pose and ‘solve problems as a skills acquisition” (p. 8).

As asserted in chapter four, it is evident that the over-representation of the level of the routine procedure may have compromised the actual weightings of the other cognitive levels, especially for the knowledge level as well as the problem-solving level.

This reflects the long-standing discord between summative assessment and the prescripts of the curriculum as reported by Pournara, Mpofu, and Saunders (2015), as well as Bansilal (2017). The way the problem-solving level was presented in the examinations is very telling of how examiners have a disregard for questions that can be categorised under this cognitive level. Not concealing the fact that the problem-solving level is expected to mostly contain never seen before and non-routine questions in the examination, perhaps, the disregard of the questions that have the nature of this cognitive level stems from the dread of having learners fail the subject. Teachers know their learners best and can predetermine the set of questions that their learners are most likely to be successful in, highlighting another important aspect of Ball et al.'s (2008) MKT framework which is the knowledge of content and that of students (KCS).

The under-representation of questions at the problem-solving level is also a reflection of the classroom practices, this is to say that one may conclude that teachers and learners do not engage in questions that involve the problem-solving level in the classroom as stated earlier. Thus, the a low representation of questions of this nature, since teachers cannot assess what they did not teach or what they do not know. The result of this practice limits the amount of learning imparted to the learners. Furthermore, learners will leave Grade 9 with a mastery of somewhat routine questions only. Yet again, the most severe implications will be witnessed each year at the release of the Grade 12 results and the reporting of results of international tests such as the TIMSS.

5.2.6 Responding to research questions one and two

Based on the discussions in sub-sections 5.2.1 to 5.2.5 I respond to the first and second sub-questions that guided this study. The first sub-question states; to what extent do the questions in Grade 9 mathematics examinations address the cognitive levels of questions prescribed in the CAPS? The second sub-question states how the questions in the Grade 9 mathematics examinations spread concerning the percentile weighting prescribed in CAPS. In relation to the first sub-question of this study the results indicated that the mathematics questions in Grade 9 school-based examinations generally addressed the cognitive levels prescribed in CAPS.

However, in relation to the second sub-question, the results indicated that there are inconsistencies across the cognitive levels in terms of percentile weightings of questions in Grade 9 mathematics examinations. The most represented cognitive level in the examinations is the level of the routine procedure. Whereas the knowledge and problem-solving levels were most underrepresented. In rare instances, in examinations from Schools B and C the level of the complex procedure conformed to the prescribed weightings in CAPS.

5.3 SCOPE OF CONTENT IN THE EXAMINATIONS

The findings pertaining to the scope of content in the examinations is discussed in this section. The five main content areas for mathematics, their spread (scope), and weightings for Grade 9 mathematics are outlined, the five content areas in mathematics include: (a) Numbers, operations and relationships; (b) Patterns, functions and algebra; (c) Space and Shape (Geometry);(d) Measurements; and (e) data-handling (DBE, 2011). For Grade 9, the content areas are allocated the weightings of 15%, 35%, 30%, 10% and 10% respectively in CAPS (DBE, 2011).

The content areas were further discussed in detail in chapter two. In the current section under the heading (§5.3) I discuss the findings on coverage of content areas that were fully addressed in the examination, [furthermore], the discussions extend to the extent to which the scope of content as specified for Grade 9 was assessed in the questions. The discussions concurrently respond to the third and fourth sub-questions of this study, viz. To what extent do the questions in Grade 9 mathematics examinations address the scope of content prescribed in CAPS? And to what extent do the questions in the Grade 9 mathematics examinations assess the scope of content as specified for Grade 9?

5.3.1 Summary of the findings on content areas

The findings about the scope of content revealed that not all the content areas prescribed in CAPS were addressed in the examinations. This is even though CAPS for mathematics in the Senior Phase (grades 7-9) draws special attention to five content areas that are important for learners to learn at Grade 9 level (DBE, 2011). Data-handling and measurement content areas were not featured in the questions in the examination from School A; however, data-handling was the only content area omitted in the examinations from Schools B and C. Thus, exhibiting a lack of alignment between the examinations and the prescripts of CAPS. This is a manifestation of what I asserted earlier in chapter two, that research seldom investigates the 'actual contents' of summative assessment in mathematics that are developed at schools,

[and], which reflect the parts of mathematics that are important for learners to learn at a particular level of their development.

Furthermore, the findings reveal that examiners are unmindful of the contents of the curriculum (CAPS) document. Thus, advancing the argument that examiners/teachers do not exhaustively exhibit their MKT suggested by Ball et al. (2008), especially KCC under the PCK domain. The implication thereof is that learners are likely to exit the general education and training (GET) phase and enter the further education and training (FET) phase without the acquisition of knowledge of all the content areas. This adds to the teaching and learning challenges already faced by teachers and learners in the FET phase. Some challenges include a lack of MKT and redeployment of teachers that leads to them being ill-equipped to teach specific concepts (Tachie, 2020).

The discrepancies in terms of percentile weightings were also revealed. Unequivocally, the DBE (2011) also indicates how the content in Grade 9 mathematics must be spread (i.e., scope). NOR and PFA was mostly overrepresented in the three examinations. Space and Shape (Geometry) had varying percentile coverage across the three schools. Measurement was not featured in the examination from School A. It was further underrepresented in examinations from Schools B and C. Data-handling was not covered at all in all three schools.

5.3.2 Numbers, Operations, and Relationships

NOR is a content area that involves the manipulation of numbers to achieve required results (solutions to mathematics problems), and to do this, learners need a deep conceptual knowledge of how to use operations, the role of the equal sign, as well as facts about numbers (Bowers, 2021). According to the DBE (2011), The general content focus of NOR is to develop a sense of numbers while the specific content focus of NOR in the senior phase involves the representation of numbers in different ways, the ability to transition freely between representations and to ‘solve problems using an increased range of numbers. Competence in the other content areas rests heavily on the knowledge of NOR. As evidenced in the findings in chapter four, in all three schools NOR exceeded the prescribed percentile weighting in CAPS. The overrepresentation of NOR in the examinations may support the findings by Carvalho and Rodrigues (2021) where they claim that an understanding of NOR is closely linked to the development of ‘problem-solving’ skills, therefore, it would not be surprising if the overrepresentation suggested that the examiners were attempting to develop the problem-solving skill in the learners. In similar understandings, as argued by Gravemeijer and Muurling (2019), the digital community of the 21st century needs extraordinary mathematical understanding, and this is associated with the development of NOR. However, the overrepresentation contrasts with what

The weightings of content areas are intended for in CAPS, i.e. “the weighting of mathematics content areas serves two primary purposes: guidance on the time needed to adequately address the content within each content area, [and] guidance on the spread of content in the examination (especially end-of-year summative assessment)” (DBE, 2011, p. 11). The findings could imply that examiners/teachers do not have proper guidance on how content must be spread in the end-of-year examinations thus an exhibition of a lack of knowledge of content and curricular (KCC).

As such, learners are likely to only acquire and become familiar with the content that they are frequently exposed to in the classroom. Learners are groomed to only respond to questions of the nature of this content area in the examinations. Thus, compromising the other content areas as they will most likely not have a slot to be taught in the classroom. Learners will enter the next grade without a foundational knowledge of the contents of other content areas.

5.3.3 Patterns, Functions, and Algebra

“A central part of this content area is for the learners to achieve efficient manipulative skills in the use of algebra” (DBE, 2011, p. 10). In addition, the DBE (2011) asserts that the language of algebra can be extended to learning about functions and relationships between variables. Flowing from the findings of NOR, PFA was also excessively represented in the examinations. One of the importance of learning algebra is that it aids learners to form generalities across situations, specifically mathematics situations (Kaput, 2008). As such, the overrepresentation of PFA in the examinations may be purposive as it might be believed that it will improve learners’ knowledge of algebraic concepts that will support the conceptual and procedural development of the topic in the classroom. In other understandings, Alibali et al. (2014)

suggested that competence in algebra has the likelihood of increasing success in later grades when engaging in more complex mathematics. I extend this view to working across other content areas, this is to say that competence in algebra may increase the likelihood of success in other content areas where generalization across the content areas may be required.

Furthermore, the findings also imply a poor comprehension of the curriculum by the examiners/teachers. The findings reveal that examiners/teachers may be spending much time teaching PFA, [and], ultimately end up over-assessing it. This is evidenced by the content area being featured in many of the questions in the examinations. Implying that the other content areas may have been inadequately taught, or that not much time and attention was rendered to them. Similarly, learners will leave Grade 9 with excessive accumulation of the contents of PFA. Thus, leaving behind a wealth of knowledge within other content areas because they did not feature much in the examination consequently.

5.3.4 Geometry

Geometry has been defined using varying ways, e.g. it involves working with axioms and proofs through deductive thinking (Mamali, 2015). Bassarea (2012) defines geometry as the study of shapes, their relationships and their properties. According to the DBE (2011), Geometry is the study of space and shape aimed at enhancing knowledge and recognition of the pattern, precision, achievement, and beauty of natural and cultural settings, while the focus is on properties, relationships, orientations, positions, and transformations of two-dimensional shapes and three-dimensional objects. Furthermore, the specific content focus of Geometry in the senior phase includes drawings and constructions, the use of constructions to investigate properties of geometric figures, and description and classification categories of geometric figures and shapes (DBE, 2011, p. 10).

Geometry content was not thoroughly assessed in the examinations from the three schools. The differences between the actual weightings and the prescribed weightings were disproportionately high in schools A and B. The differences were 10% and 17% respectively. Although geometry was also misrepresented in the examination from School C, the misrepresentation had a difference of 1% from the two-percentile threshold for compliance. Perhaps the underrepresentation was caused by the consistently high representations of NOR and PFA. Geometry is important globally for being a source of visualization for understanding procedures, algebra, and statistical concepts (Binti, Tay, & Lian, 2004).

In the scientific world, the importance of geometry is seen naturally in many sectors that include learning about the solar system and geography (Tachie, 2020). The underrepresentation of geometry in the examinations may be the rationale for Chihambakwe's (2017) report on the declining performance of learners in mathematics examinations, particularly where geometry is concerned. Furthermore, the findings support the view that geometry is not only difficult for learners to learn, but it is equally difficult for teachers to teach and assess it (Tachie, 2020).

It is also important to note that several historical challenges confronting the teaching and learning of geometry have been identified that may have led to the misrepresentation of the content area in the examinations. Among the challenges, curriculum reforms during and after apartheid have led to many teachers not being taught some aspects of geometry during their teacher training and secondary schooling (Tachie, 2020). This means that teachers may have been taught some aspects of geometry, but they do not appeal to the current demands of teaching and assessing geometry.

Tachie (2020) further asserts that the paucity of literature on how teachers cope with teaching/assessing geometry is a cause for concern since geometry was previously excluded from the curriculum. To share some light, teachers that graduated pre-2013 are most likely to have not been taught geometry during their teacher training (Tachie, 2013). Furthermore, little is known about how they cope with teaching/assessing it since it was introduced at the school level in 2012. Considering the resurgence of the percentile weighting of geometry set out in the DBE (2011) as learners progress through the senior phase its misrepresentation poses a drastic threat to performance expectations of the learners in mathematics as a subject. In turn, this implies that teachers in the next grade (Grade 10) might have to spend more time attempting to cover the content that was missed in Grade 9.

Another possible reason for the misrepresentation could emanate from the confusion that exists between geometry and measurement content. As stated in chapter four, it might be a lot easier for examiners to assume that content that belongs to geometry is categorized as measurement content, and vice versa. For instance, it is my argument that it is a lot easier for people who do not teach mathematics and for examiners that do not have adequate knowledge of the curriculum to classify questions that contain the theorem of Pythagoras as space and shape (Geometry) questions whereas is a measurement question/content. It is also quite possible to pitch the questions involving the theorem of Pythagoras at a lower level than is required for Grade 9.

Furthermore, a likely end result with limited knowledge of geometry might lead to learners not being successful in responding to measurement questions. In dealing with measurement content, a lot of geometric figures (geometry content) are involved, since this is the case, measurement questions usually involve the measurement of parts of geometric figures that are taught under geometry content. Therefore, if learners do not have a sense of geometry knowledge, they cannot feasibly be successful in gaining and being successful in dealing with measurement content. Ubah and Bansilal (2019), and Alex and Mammen (2018) have identified geometry skills as vital for the economic advancement of countries since geometry skills are key in construction work, architecture, and engineering. The situation revealed in the examination papers does not paint an encouraging picture regarding improving the scarce skills currently facing South Africa.

5.3.5 Measurement

In the senior phase, measurement focuses on the selection and use of appropriate units, instruments, and formulae that quantify the characteristics of shapes, objects and the environment (DBE, 2011). Specifically, in Grade 9, the focus is on using formulae to measure the area, perimeter, surface area, and volume of geometric figures and solids (DBE, 2011). This means that measurement quantifies the properties of geometric figures. Considering the statement, it is my view that measurement is important in applying the knowledge learned in other content areas apart from geometry, such as NOR and PFA. Furthermore, measurement guides the selection of and cohesion between appropriate units of measurement and allows for the use of the theorem of Pythagoras to solve right-angled triangle problems (DBE, 2011). However, Measurement was the second most underrepresented content area in the examinations. In Schools A and C, it can be concluded that there were no traces of measurement content in the examinations. It was also underrepresented in the examination from School B although the underrepresentation was not by a high margin.

Thus, revealing teachers lack of understanding of CAPS. Furthermore, this indicates that little to no time is spent teaching the content area. Therefore, the burden of work that teachers have in the FET phase is increased, as they would be faced with the challenge of teaching learners who know little to nothing about measurement and its contents. This is a serious problem because in the FET phase measurement and geometry are combined to form a content area under the umbrella name 'Euclidean geometry and measurement' (DBE, 2011).

5.3.6 Data handling

In the CAPS policy document, the purpose of data-handling is to enable learners to develop skills to collect, display, organize, and interpret numeric data (DBE, 2011). In learning data-handling learners must interpret data from different contexts to make informed judgments (Odu & Gosa, 2014). Data-handling was excluded in all the examinations. This is a significant showcase of the examinations not being in line with CAPS. Furthermore, based on these findings it appears that data-handling forms part of the challenges confronting the teaching and learning of mathematics. As a result, learners are not adequately imparted with sufficient content necessary for their learning and development in Grade 9.

The examinations can be classified as being of poor quality because they do not assess the full spectrum of the contents of CAPS. Thus, the examiners/teachers are also of substandard quality because according to Moss (2013) the quality of summative assessment depends on the quality of the assessor/teacher. To elucidate further, North and Scheiber (2008) argued the fact that statistical literacy was important due to all the technological advances taking place globally. According to Odu and Gosa (2014), this argument prompted curriculum developers in South Africa to make data-handling an integral part of CAPS. However, the findings reveal that the reality of data-handling teaching, and learning is that it is excluded from examinations. In addition, this practice defies the definition of summative assessment set forth by Harrison et al. (2015) which states that summative assessment determines whether learners are ready to be promoted to the next level of learning (in this case the next level Grade 10). It is my opinion that the learners are not entirely ready if one or more of the content areas listed in CAPS are not addressed in an end-year examination.

Furthermore, the feedback given to parents and learners and the meaning of it thereof is not a true reflection of the learning that was supposed to have taken place as it is not fully in line with the prescripts of CAPS as was suggested by Dolin et al. (2018). In closing, the exclusion of data-handling from the examination deprives learners who are statistically inclined of the opportunity to express their knowledge of the content area.

5.3.7 Responding to research questions three and four

The results of the findings that bear on content areas indicated that the examinations were not aligned with the prescripts of the curriculum CAPS. In relation to both sub-questions three and four viz. To what extent do the questions in Grade 9 mathematics examinations address the content areas prescribed in CAPS? And to what extent do the questions in the Grade 9 mathematics examinations assess the scope of content as specified for Grade 9? The examinations were found lacking to address the full spectrum of mathematics content areas prescribed in CAPS for Grade 9.

Moreover, comparisons of the content areas that were assessed (in the examinations) had a contradiction in terms of weightings with those prescribed in CAPS. For instance, NOR and PFA were excessively bestowed within the examinations. In some instances, the representations exceeded the prescribed weightings by over 15%. Concurrently, Geometry content and Measurement content were bestowed opposite to how NOR and PFA were presented. The most extreme case was realised with data-handling where results indicated that the content area was not part of any of the examinations. Thus, a comparison could not be made. The examinations also could not present the full scope of the examination as prescribed in CAPS.

5.4 REFLECTING ON THE AFFORDANCE OF THE THEORETICAL FRAMEWORK

I have opted for two theoretical lenses through which to analyse school-based summative assessment, specifically mathematics end-of-year examination. The two theoretical lenses include the: (a) CAPS cognitive levels (DBE, 2011) whose ancestry is traced to 1999 TIMSS cognitive levels (TIMSS Database User Guide, 1999), and (b) Mathematics Knowledge for Teaching (MKT) (Ball et al., 2008) which evolved from the seminal work by Shulman (1986) on professional knowledge for teaching. The DBE classifies items in assessment according to four cognitive levels each with a descriptor and percentile weighting (see Appendix A) namely Knowledge, Routine procedures, Complex procedures, and Problem-solving.

According to Ball et al. (2008), teacher knowledge is divided into two broad domains subject matter knowledge (SMK) and Pedagogical content knowledge (PCK). Three subdomains make up SMK: common content knowledge (CCK), specialised content knowledge (SCK), and horizon content knowledge (HCK). Pedagogical content knowledge also has three subdomains: knowledge of content and teaching (KCT), knowledge of content and students (KCS) and knowledge of content and the curriculum (KCC). Teachers/examiners need to provoke this knowledge when assessing learners.

The theoretical framework chosen for this study served as a unification unit. I.e., the theoretical framework assisted me to put together all aspects pertaining to the research study, starting with the formulation of my research title and flowing to the discussion of the results. Specifically, the theoretical framework assisted me with identifying a research topic and subsequently coming up with a title and literature that supported my research. Most prominently, the theoretical framework assisted me to develop and iterate the research questions that guided this study and were based on the mathematics knowledge that teachers need to have and the prescripts of CAPS.

Regarding the literature review, the theoretical framework assisted me with the search and selection of relevant literature surrounding the teaching and learning of mathematics and the knowledge that teachers/examiners need to have. Furthermore, the theoretical framework assisted me by guiding the organization of the subheadings under the literature review chapter. Due to the nature of how CAPS is presented (needs to be interpreted) it was also so not difficult to choose the interpretivist paradigm as the research philosophy through which the study could be viewed. The interpretivist paradigm assisted me to make methodological choices that in turn assisted me to develop data collection instruments that allowed me to rigorously collect, analyze and interpret data. Leading up to the presentation of the findings, whose main data collection instruments are based on CAPS cognitive levels and scope of content for Grade 9 mathematics. The discussions and arguments in the discussions chapter were mainly guided by the theoretical framework as seen in the constant reference to Cognitive levels of CAPS and MKT.

5.5 LIMITATIONS OF THIS STUDY

As with most studies, the design of the current study is subject to limitations. The three prominent limitations of this study are as follows: the first is that this study provides little basis for generalisation since the case study was adopted as a research design (Crowe et al. 2011). Therefore, the findings of this study cannot be generalised to other (larger) populations. The second limitation concerns my own bias when analysing the examinations, as a mathematics educator I have my feelings and beliefs about how to classify questions in examinations into cognitive levels and content areas. However, an effort was made to minimise my bias through intercoder reliability (ICR) involving a CAPS specialist who interpreted the data. The third limitation pertains to the exclusion of interviews in the study. In interviewing the examiners, I would have uncovered more information regarding the omissions and/or overrepresentations of the cognitive levels and content areas.

5.6 RECOMMENDATIONS

5.6.1 Recommendations for future practice

The results have indicated the significance of having a quality summative assessment in the form of end-of-year examinations that are aligned to the prescripts of the curriculum (CAPS). Therefore, I recommend a slot in the mathematics memoranda that will be in the form of an examination framework to be used by examiners to verify cognitive levels, content areas, as well as their correct weightings. Moreover, while the two-percentile threshold for compliance (for content areas) is suggested by CAPS and is used in this study, I recommend a review of CAPS to allow a two-percentile deviation as compliance to the estimates that are already in place in terms of weightings of cognitive levels, to guide how teachers use cognitive levels in assessment. Furthermore, I recommend that teacher training institutions do more to adequately fill the knowledge and skills gaps that pertain to mathematics assessment and the uses and guidelines provided for in CAPS.

5.6.2 Recommendations for future research

The current study investigated the extent to which mathematics examinations align with the prescripts of the curriculum (CAPS). The data that made up the findings of this study manifested through the aid of CAPS and MKT. The findings in part revealed that examiners seem to have limited knowledge of the curriculum, thus, they have limited MKT. The findings also revealed in part; the examination practices that involve the omission of contents of certain content areas, for instance, data-handling. This implies that there is still a paucity of information about how to measure teachers' MKT, and how much of it is revealed in practice once it is measured. Therefore, I recommend that other studies be conducted to investigate the comparisons of teachers' measured MKT and the MKT they reveal in practice, especially when examining a neglected content area such as data-handling. Furthermore, other studies can investigate how the mathematics examination framework can be used to improve the compliance of examinations with the curriculum.

5.7 CONCLUSION

The skills that mathematics teachers have of developing and administering acceptable learner assessments were identified as being of poor quality. In support of this claim, Van der Berg and Shepard (2015) found that teachers develop learner assessments that are of a poor standard at schools and as a result, low-quality feedback is communicated to learners and parents. In studies conducted by Moodaly (2010) as well as Berger, Bowie and Nyaumwe (2010) it was revealed that Grade 12 mathematics examinations in South Africa lacked alignment with the prescripts of the curriculum. If this was the case with the high-stake Grade 12 examination, one can assume that the situation could be dire in the lower grades. Furthermore, to indicate that assessment has been a neglected and long-standing issue in education, Vandeyer and Killen (2003) revealed that teachers were struggling to deal with the assessment requirements of former curriculum policies in South Africa. The issue of educators struggling with assessment requirements is still prevalent with the current curriculum (CAPS) with little being done to address it (Maharajh, Nkosi & Mkhize, 2016). Therefore, the primary purpose of the current study was to explore summative assessment in mathematics in South Africa to determine the extent to which the examinations are aligned to the prescripts (the range of cognitive levels and spread of content) of CAPS (DBE, 2011) that guides teaching, learning and assessment in public schools.

The literature review assisted me with an overview of literature pertaining to summative assessment and how it is developed and administered in South African mathematics education. Thus, building up the foundation of knowledge that formed part of and guided this study to completion. Furthermore, the study was approached from two theoretical lenses that included the: (a) CAPS cognitive levels and (b) MKT. the theoretical framework assisted me in three ways: to collect data, to address the research questions, and to address the research problem.

In relation to cognitive levels, the findings revealed that the examinations in Schools A, B, and C were competent to feature all the cognitive levels prescribed in CAPS. However, the examinations failed to accurately interpolate questions to match the expected weightings for each cognitive level as in CAPS. Despite the (CAPS) two-percentile threshold for compliance recommended in chapter four, the actual weightings of the cognitive levels were quite different from the expected weightings. This difference in the weightings can be attributed to the excessive representations of the routine procedures level questions. The knowledge level, Complex procedures level as well as problem-solving level questions were mostly underrepresented. This underrepresentation of the three levels was also evident in the number of questions that featured these levels. The comparisons of the actual and expected weightings also shed light on a great deal of discrepancies among and across the cognitive levels.

The findings pertaining to the scope of content revealed that the examinations in Schools A, B, and C were incompetent to cover the full scope of the examination prescribed in CAPS. In other words, the five key content areas for the senior phase in mathematics were not fully featured in the examinations. In particular, and, in a direr instance, data-handling questions were not featured in any of the examinations. Measurement questions were largely underrepresented, while geometry questions could be said to have been fairly represented, although also not complying with the two-percentile threshold asserted in chapter four. PFA had the highest representation in all the examinations followed by NOR. The comparisons of the actual weightings and the expected weightings illustrated that too much emphasis put on PFA by the examiners results in the content areas not being featured in the examination.

The findings of this study in relation to the sub-questions revealed that examiners are aware of the curriculum pertaining to the spread of cognitive levels and not the scope of the content. Furthermore, examiners typically do not adhere to the prescripts of the curriculum regarding the weightings of cognitive levels as well as content areas. In relation to the primary research question viz., what is the extent of alignment between the Grade 9 mathematics summative assessment and the prescripts of CAPS? There were instances where the findings revealed that compliance with the prescripts of the curriculum. However, the most consistent revelation was that examinations did not align with the prescripts of CAPS.

REFERENCES

Abdelhakim, A. S. (2021). Adopted Research Designs by Tourism and Hospitality Postgraduates in The Light of Research Onion. *International Journal of Tourism and Hospitality Management*, *4*(2), 98-124.

Adler, J. and Venkat, H. (2014) Teachers' mathematical discourse in instruction: Focus on examples and explanations. In Venkat, H., Rollnick, M., Loughran, J. and Askew, M. (Ed), *Exploring mathematics and science teachers' knowledge: Windows into teacher thinking*. Oxford: Routledge. Pp. 132-146.

Odu, E. O., & Gosa, L. J. (2014). The teaching and learning of data-handling in primary schools: South African Experience. *Mediterranean Journal of Social Sciences*, *5*(23), 814-814.

Alex, J., & Mammen, K.J. (2018). Students' understanding of geometry terminology through the lens of Van Hiele's theory. *Pythagoras, 39(1)*, 1-8. https://doi.org/10.4102/pythagoras.v39i1.376

Alharbi, A., Alosaimi, W., Sahal, R., & Saleh, H. (2021). Real-time system prediction for heart rate using deep learning and stream processing platforms. *Complexity*, *2021*, 1-9.

Alibali, M. W., Nathan, M. J., Wolfgram, M. S., Church, R. B., Jacobs, S. A., Johnson Martinez, C., & Knuth, E. J. (2014). How teachers link ideas in mathematics instruction using speech and gesture: A corpus analysis. *Cognition and instruction, 32(1),* 65-100.

Alturki, R. (2021). Research onion for smart IoT-enabled mobile applications. Scientific Programming, 2021.

Andrade, C. (2021). The inconvenient truth about convenience and purposive samples. *Indian Journal of Psychological Medicine, 43(1),* 86-88.

Asenahabi, B. M. (2019). Basics of research design: A guide to selecting appropriate research design. *International Journal of Contemporary Applied Research, 6(5),* 76-89.

Bacquet, J., N. (2022). Implications of summative and formative assessment in Japan- A review of the current literature. *International Journal of Education and Literacy Studies, 8(2*), 28-35. https://doi.org/10.7575/aiac.ijels.v.8n.2p.28

Ball, D. L., & Bass, H. (2008). The role of mathematics in education for democracy. In G. Fenstermacher (Series Ed.) & D. Coulter, & J. Wiens (Vol. Eds.), *Yearbook of the National Society for the Study of Education*: Vol. 107 (1). *Why do we educate in a democratic society?* (pp. 171–184). Malden, MA: Blackwell Publishing

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content Knowledge for teaching: What makes it special? *Journal of teacher education, 59(5),* 389-407. http://dx.doi.org/10.1177/0022487108324554

Bansilal, S. (2017). The difficulty level of a national assessment of Grade 9 mathematics: The case of five schools. *South African Journal of Childhood Education, 7(1)*, a412. https://doi.org/10.4102/sajce.v7i1.412

Bassarear, T. (2012). *Mathematics for elementary school teachers*(5thEd.). Cengage Learning.

Bautista, G., & Isoda, M. (2017). A 2-Dimensional matrix for analyzing mathematical tasks. In B. kaur, W. Ho, T. Toh, B. Choy. (Eds). *Proceedings of the 41st Conference of the international group for the psychology of mathematics education* (pp. 137-144). Singapore: PME.

Berger, M., Bowie, L., & Nyaumwe, L. (2010). Taxonomy matters Cognitive levels and types of mathematical activities in mathematics examinations. *Pythagoras, 71*, 30-40. https://doi.org/pythagorus.v0i71.4

Bosman, A., & Schulze, S. (2018). Learning style preferences and mathematics achievement of secondary school learners. *South African Journal of Education, 38(1),* 1-8.

Binti, N., Tay, I., & Lian., B. (2004). Teaching and learning of geometry: Problems and prospect. *Masalah Pendidikan Jilid, 27,* 165-178.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9(2)*, 27-40. https://doi.org/10.3316/QRJ0902027

Bowers, B. E. (2021). Teachers identifying and responding to learner errors and misconceptions in Numbers, Operations and Relationships in the Intermediate Phase (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Braun, H., Kanjee, A. (2006). *Improving education through assessment, innovation, and evaluation*. Cambridge: American Academy of Arts and Sciences

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3(2),* 77-101.

Brown, G. T., & Hirschfeld, G. H. (2008). Students 'conceptions of assessment: Links to outcomes. *Assessment in Education: Principles, Policy & Practice, 15(1),* 3-17.

Burney, S.M.A; Saleem, H., (2008), "Inductive & Deductive Research Approach", Lecture delivered on 06-03-2008 at Auditorium of Faculty of Arts and Science, University of Karachi, Karachi, Pakistan.

Carvalho, R., & Rodrigues, M. (2021). Mental computation: an overview on this special issue. *Journal of Mathematics Education, 14(1),* 1-5.

Chapman, O. (2013). Investigating teachers' knowledge for teaching mathematics. *Journal of Mathematics Teacher Education, 16*, 237–243. https://doi.org/10.1007/s10857-013-9247-2

Chihambakwe, T. (2017). Impact of national senior certificate examination diagnostic report on learner performance in mathematics (Unpublished Masters dissertation). University of Zululand, Pietermaritzburg

Christians, C. G. (2011). Ethics and politics in qualitative research. In N.K. Denzin & Y.S. Lincoln (Eds), the sage handbook of qualitative research (pp. 61-80). Thousand Oaks, CA: SAGE publications

Connor, C. M., Mazzocco, M. M., Kurz, T., Crowe, E. C., Tighe, E. L., Wood, T. S., & Morrison, F. J. (2018). Using assessment to individualize early mathematics instruction. *Journal of School Psychology, 66,* 97-113.

Crowe, S., Creswell, K., Robertson, A., Huby, G., & Sheikh, A. (2011). The case study approach. *BMC Medical research methodology, 11(1)*, 100. http://dx.doi:10.1186/1471-2288-11-100

Davies, C., & Fisher, M. (2018). Understanding research paradigms. *Journal of the Australian Rehabilitation Nurses Association, 21(3),* 21-25. http://search,informit.org/doi/10.2216/informit.160174722074

Department of Basic Education. (2008). National Curriculum Statement Grades 10-12 (General): Subject Assessment Guidelines-Mathematics. Pretoria: South Africa. Government Printers.

Department of Basic Education. (2011). Curriculum and Assessment Policy Statement (CAPS) Mathematics. Pretoria: Government Printers.

Department of Basic Education. (2011). Report on the Annual National assessment of 2011. Pretoria: Government Printers.

Department of Basic Education. (2013). Report on the Annual National Assessment of 2012. Pretoria: Government printers.

Department of Basic Education. (2014). Report on the Annual National Assessment of 2013. Pretoria: Government printers.

Department of Basic Education. (2015). Report on the Annual National Assessment of 2014. Pretoria: Government printers.

Department of Basic Education. (2018). PROTOCOL DOCUMENT ON TEACHER DIAGNOSTIC ASSESSMENTS. Pretoria: Government Printers.

Dixson, D. D., & Worrel, F. C. (2016). Formative and summative assessment in the classroom. *Theory into practice, 55(2),* 153-159.

Dolin, J., Black, P., Harlen, W., & Tiberghien, A. (2018). Exploring the relation between formative and summative assessment. In J. Dolin & R. Evans (Eds.), *Transforming Assessment* (pp. 53-80). Cham, Switzerland: SPRINGER.

Dube-Xaba, Z., & Xulu, R. (2020). Opportunities and challenges in school based assessment: Tourism learners' views. *African Journal of Hospitality, Tourism and Leisure*, *9*(2), 1-15.

Du Plooy, R., & Long, C. (2013). *Engaging with cognitive levels: A practical approach towards assessing the cognitive spectrum in mathematics*. In AMESA Conference in Kimberley.

Elo, S., & Kyngas, H. (2008). The qualitative content analysis process. Sociology Journal of advanced nursing, 62, 107-115. http://dx.doi.org/10.1111/j.1365-2648.2007.04569x

Emmel, N. (2013). Purposeful Sampling. In N. Emmel (Ed), *Sampling and choosing cases in qualitative research: A realist approach* (pp. 33-34). SAGE publications.

Flick, U. (2014). *An introduction to qualitative research* (5th ed.). London: Sage Publications Ltd

Flick, U. (2018). *The Sage handbook of qualitative data collection*. Berlin: SAGE publications.

Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in Interdisciplinary STEM education. *International Journal of STEM Education, 7(1),* 1-14. https://doi.org/10.1186/s40594-020-00225-4

Gemma, R. (2018). Introduction to positivism, interpretivism and critical theory. *Nurse researcher, 25(4),* 41-49. https://doi.org/10.7748/nr.2018.e1466

Gezer, T., Wang, C., Polly, A., Martin, C., Pugalee, D., & Lambert, R. (2021). The Relationship between Formative Assessment and Summative Assessment in Primary Grade Mathematics Classrooms. *International Electronic Journal of Elementary Education, 13(5),* 673–685. Retrieved from https://www.iejee.com/index.php/IEJEE/article/view/1508

Graneheim, U. H., Lindgren, B. M., & Lundman, B. (2017). Methodological challenges in qualitative content analysis: A discussion paper. *Nurse Education Today, 56,* 29-34. http://dx.doi.org/10.1016/j.nedt.2017.06.002

Gravemeijer, K., & Bruin-Muurling, G. (2019). Fostering process-object transitions and a deeper understanding of the domain of numbers. *Quadrante, 28(2),* 6-31.

Grbich, C. (2012). *Qualitative data analysis: An introduction*. sage.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic enquiries. *Educational Communication and Technology Journal, 29,* 75-91.

Gustafsson, J. (2017). *Single case studies vs. multiple case studies: a comparative study* (thesis). Halmstad, Sweden: Halmstad University.

Harlen, W., Crick, R. D., Gardner, J., James, M., Broadfoot, P., Daugherty, R., Stobart, G., & Dudley, P. (2002). *A systematic review of the impact of summative assessment and tests on students' motivation for learning.* In Evidence for Policy and Practice Information and Co-Ordinating Centre. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Harris, D. (2019). *Literature review and research design: A guide to effective research practice.* Routledge.

Harrison, C. J., Konings, K. D., Schuwirth, L., & Wass, V. (2015). Barriers to the uptake and use of feedback in the context of summative assessment. *Advanced Health Sci Educ Theory Pract, 20(1),* 229-245.

Heale, R., & Twycross, A. (2017). What is a case study? *Evidence-Based Nursing, 21(1)*, 7-8. http://dx.doi.org/10.1136/eb-2017-102845

Hiebert, J. & Carpenter, T. P. (1992). Learning and teaching with understanding. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: a project of the National Council of teachers of mathematics*. 65-97. New York: Macmillan.

Holmes, V.L. (2012). Depth of Teachers' Knowledge: Frameworks for Teachers' Knowledge of Mathematics. *Journal of STEM Education: Innovations and Research, 13,* 55-71.

Hoover, M., Mosvold, R., Ball, DL., & Lai, Y. (2016). Making Progress on Mathematical Knowledge for Teaching. *The Mathematics Enthusiast, 13(1),* 1-34. https://doi.org/10.54870/1551-3440.1363

Howie, S. J. (2012). High-stakes testing in South Africa: Friend or foe? *Assessment in Education Principles Policy and Practice, 19(1),* 81-98.

Inayah, S., Septian, A., & Suwarman, R. F. (2020). Student procedural fluency in numerical method subjects. *Desimal: Jurnal Matematika, 3(1),* 53-64.

Islam, M. S., & Stapa, M. (2019). Investigation the potentials of classroom assessment: A critical discussion. *International Journal of Engineering and Advanced Technology (IJEAT), 2249, (8)5*, 1172-1179. https://doi.org/10.35940/ijeat.E1165.0585C19

Jita, L. C., & Ige, O. A. (2019). South African teachers' mathematical knowledge: Reflections from the short learning intervention programme. *Problems of Education in the 21st Century, 77(6),* 705-721. https://doi.org/10.33225/pec/19.77.705

Juan, A., Reddy, V., & Arends, F. (2020). TIMSS 2019: Highlights of South African Grade 9 results in Mathematics and Science. Retrieved from http://www.governmentpublications.lib.uct.ac.za/news/timss-2019-highlights-south-african-Grade-9-results-mathematics-and-science accessed on 29 JANUARY 2021.

Kapukaya, K. (2013). Assessment: A help or hindrance to educational purposes. *International Journal of Humanities and Social Science, 3(6),* 84-93.

Kaput, J. (2008) What Is Algebra? What Is Algebraic Reasoning? In: Kaput, J.J., Carraher, D.W. and Blanton, M.L., Eds., *Algebra in the Early Grades,* Lawrence Erlbaum Associates, New York, 5-17

Kibble, J. D. (2017) Best practices in summative assessment. *Advances in Physiology Education, 41(1),* 110-119.

Kilpatrick, J. (2001). Understanding mathematical literacy: The contribution of research. *Educational studies in mathematics, 47(1),* 101-116.

Kitchener, K. S., & Kitchener, R. F. (2009). Social science research ethics: Historical and philosophical issues. In D. M. Mertens & P. Ginsberg (Eds.). *Handbook of social ethics* (pp. 5-22). Thousand Oaks, CA: SAGE publications

Kivunja, C. & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts*. International Journal of Higher Education, 6(5),* 26-41.

Kivunja, C. (2015). Why students don’t like assessment and how to change their perceptions in 21st-century pedagogies. *Creative Education, 6,* 2117-2126.

Krippendorff, K. (2013). *Content Analysis. An introduction to its methodology.* London: SAGE Publications.

Lambert, D., & Lines, D. (2000). *Understanding assessment*. London: Routledge Falmer.

Le Bow, J. L., Chambers, A. L., Christensen, & Johnson, S. M. (2012). Research on the Treatment of couple distress. *Journal of Marital and Couple Therapy, 38(1),* 145-168.

Lincoln, Y. S. (1995). Emerging criteria for quality in qualitative and interpretive research*. Qualitative Enquiry, 1*, 275-289.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Enquiry*. Beverly Hills, CA: SAGE publications.

Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2011). Paradigmatic controversies, contradictions, and emerging confluences revisited. In N.K. Denzin & Y.S. Lincoln (Eds.), *the sage handbook of qualitative research* (pp. 97-128). Thousand Oaks, CA: SAGE publications

Makgato, M., & Mji, A. (2006). Factors associated with high school learners’ poor performance: A spotlight on mathematics and physical science. *South African Journal of Education, 26(2),* 253-266.

Mamali, N. R. (2015). *Enhancement of learner's performance in geometry at secondary schools in Vhembe District of the Limpopo Province* (Doctoral dissertation).

Mapolelo, D., & Akinsola, M.K. (2015). Preparation of mathematics teachers: Lessons from a review of literature on teachers’ knowledge, beliefs, and teacher education. *American Journal of Educational Research, 2,* 1-12.

Mardiana, S. (2020). Modifying Research Onion for Information Systems Research. *Solid State Technology, 63(4),* 5304-5313.

Marrying, P. (2000). Qualitative content analysis. *Forum Qualitative Social Research, 1(2).*

Mayring, P. (2004). Qualitative content analysis. *A companion to qualitative research, 1(2),* 159-176.

McCusker, K., & Gunaydin, S. (2015). Research using qualitative, quantitative, or mixed methods and choices based on the research. *Perfusion, 30(7),* 537- 543.

Melnikovas, A. (2018). Towards an explicit research methodology: Adapting research onion model for futures studies. *Journal of Futures Studies, 23(2),* 29-44.

Moloto, M., & Machaba, F. (2021). Grade 6 teachers' mathematical knowledge for teaching the concept of fractions. *Journal for the Education of Gifted Young Scientists, 9(4),* 283-297. http://dx.doi.org/10.17478/jegys.1000495

Moodaly, S. (2010). *An exploration of mathematical literacy teachers' design of ML assessment tasks.* Unpublished BEd (Hons) research report, University of KwaZulu-Natal, Durban

Moss, C. M. (2013). Research on classroom summative assessment. In J. H. McMillan (Eds.), *Sage handbook of research on classroom assessment* (pp. 325-356). Thousand Oakes, CA: SAGE Publications, Inc.

National Assessment of Educational Progress (NAEP). (2008). *Mathematics framework for the 2009 national assessment of educational progress*. Washington, DC: National Assessment Governing Board.

North, D. & Scheiber, J. (2008). Introducing statistics at school level in South Africa: The crucial role played by the National Statistics Office in training in-service teachers. In C. Batanero, G. Burrill, C. Reading, & A. Rossman (Eds.), *Proceedings of the 18th ICMI Study Conference and 2008 IASE Round Table Conference*

O'Connor, C., & Joffe, H. (2020). Intercoder reliability in qualitative research: debates and practical guidelines. *International journal of qualitative methods, 19,* 1609406919899220.

Palomba, C., & Banta, T. W. (1999). *Assessment essentials: Planning, implementing and improving assessment in higher education*. San Francisco: Jossey-Bass Inc.

Park, Y. S., Konge, L., & Artino, R. (2020). The positivism paradigm of research. *Journal of the Association of American Medical Colleges, 95(5),* 690-694.

Paul, J., & Criado, A.R. (2020). The art of writing a literature review: What do we know and what do we need to know? *International Business Review, 29,* 101-717.

Phelps, G., & Howell, H. (2016). Assessing Mathematical Knowledge for Teaching: The Role of Teaching Context*. The Mathematics Enthusiast, 13(1),* 52-70.

Pope, C., Ziebland, S., & Mays, N. (2000). Qualitative research in health care: Analysing qualitative data. *BMJ: British Medical Journal, 320(7227),* 114.

Potter, A. (2002). Measuring the content of instruction: Uses in research and practice. *Educational Researcher, 31(7),* 3-14.

Pournara, C., Sanders, Y., & Mpofu, S. (2015). The Grade 9 Maths ANA: What can we see after three years? *Learning and Teaching Mathematics, 18*, 34-41.

Rahman, M. S. (2020). *The advantages and disadvantages of using qualitative and quantitative approaches and methods in language "testing and assessment" research: A literature review*.

Rebuplic of South Africa (1998). The Employment of Educators Act 76 of 1998. Pretoria: Government Printers.

Rittle-Johnson, B., & Schneider, M. (2015). *Developing conceptual and procedural knowledge of mathematics*. Oxford handbook of numerical cognition, 1118-113

Robitaille, D. F., & Garden, R.A. (1996). *TIMSS Monograph no. 2: Research questions and study design.* Vancouver, Canada: Pacific Education Press.

Rogers, J., Patton, A. H., Harmon, L., Lex, A., & Meyer, M. (2020). Insights from experiments with rigour in an evobio design study. *IEEE Transactions on Visualization and Computer Graphics, 27(2),* 1106-1116.

Sahay, A. (2016). Peeling Saunder's research onion. *Research Gate, Art,* 1-5.

Sallee, M. W., & Flood, J. T. (2012). Using qualitative research to bridge research, policy, and practice. *Theory Into Practice, 51(2),* 137-144. http://dx.doi.org/10.1080/00405841.2012.662873

Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students.* England: Pearson Education Limited.

Schwartz-Shea, P., & Yanow, D. (2012). *Interpretive research design: Concept and Process.* Milton Park: Routledge.

Sileyew, K. J. (2019). *Research design and methodology* (pp. 1-12). Rijeka: IntechOpen.

Selling, S.K., Garcia, N., & Ball, D.L. (2016). What Does it Take to Develop Assessments of Mathematical Knowledge for Teaching? Unpacking the Mathematical Work of Teaching. *The Mathematics Enthusiast, 13(1),* 35-51. https://doi.org/10.54870/1551-3440.1364

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15(2),* 4-14.

Silverman, D. (2010). *Qualitative research*. London: Sage.

Singh, A. S., & Masuku, M. B. (2013). Fundamentals of applied research and sampling techniques. *International Journal of Medical and applied sciences, 2(4),* 124-132.

Sinha, T., Clarke, S., & Farquharson, L. (2018, July). *Shrek, Saunders, and the Onion Myth: Using Myths, Metaphors and Storytelling*. In ECRM 2018 17th European Conference on Research Methods in Business and Management (p. 366). Academic Conferences and publishing limited.

Smith, K. J. (2016). *Nature of Mathematics*. Cengage Learning.

South African Schools Act (1996). Cape Town: President's office. *(Government Gazette, Vol. 377, No. 175790).*

Spaull, N., & Kotze, J. (2015). Starting behind and staying behind in South Africa: The case of insurmountable learning deficits in mathematics. *International Journal* *of Educational Development, 41,* 13-24. http://dx.doi.org/10.1016/j.ijedudev.2015.01.002

Stein, M., & Smith, M. S. (1998). Mathematical tasks as a framework for reflection: From research to practice. *Mathematics Teaching in the Middle School, 3(4),* 268-275.

Stemler, S. E. (2018). *Emerging trends in content analysis. Emerging Trends in the Social and Behavioural Sciences*. John Wiley & Sons, inc.

Suurtman, C., Thomson, D. R., Kim, R. Y., Moreno, L. D., Sayac, N., Schukajlow, S., Silver, E., Ufer, S., & Vos, P. (2016). *Assessment in mathematics education: Large-scale assessment and classroom assessment* (1st ed). Hamburg: Springer.

Tachie, S. A. (2020). The challenges of South African teachers in teaching euclidean geometry*. International Journal of Learning, Teaching and Educational Research, 19(8),* 297-312

Taherdoost, H. (2016). Sampling methods in research methodology: how to choose a sampling technique for research. *International Journal of Academic Research in Management, 5(2),* 18-27.

Taylor, S. (2013). *South Africa's participation in TIMSS, PIRLS, SACMEQ and ANA B.*

Thanh, N. C., & Thanh, T.T. (2015). The interconnection between interpretivist paradigm and qualitative methods in education. *American Journal of Educational Science, 1(2),* 24-27.

Treharne, G., & Riggs, D. W. (2014). Ensuring quality in qualitative research. In *Qualitative research in clinical psychology* (pp. 57 -73). Palgrave

Trends in International Mathematics and Science Study (1995). *Study instruments and procedures* (n.d.). Retrieved May 10, 2021, from https://timssandpirls.bc.edu/timss1995i/t95.study.html

Trends in International Mathematics and Science Study (2001). *TIMMS 1999 User Guide for the International database*. Chestnut Hill, MA: ISC Lynch School of Education Boston College

Trends in International Mathematics and Science Study (2003). *Assessment frameworks and specifications 2003.* Chestnut Hill, MA: ISC Lynch School of Education Boston College.

Trends in International Mathematics and Science Study South Africa. (2015). Understanding mathematics and science achievement amongst Grade 9 learners in South Africa. Cape Town: HSRC Press.

Ubah, I., & Bansilal, S. (2019). The use of semiotic representations in reasoning about similar triangles in Euclidean geometry. *Pythagoras, 40(1), 1-10.* https://doi.org/10.4102/pythagoras.v40i1.480

Usiskin, Z. P. (2012). *What does it mean to understand some mathematics?* 12th International Congress on Mathematical Education held in Seoul, Korea, 8-15 July 2012, 502-521. Seoul, Korea: COEX.

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

Van der Berg, S., & Shepard, D. (2015). Continuous assessment and matriculation examination marks An empirical examination. *South African Journal of Childhood Education, 5(2),* 78-94.

Vandeyer, S., & Killen, R. (2003). Has curriculum reform in South Africa really changed assessment practices, and what promises that the revised National Curriculum Statement hold? *Perspectives in Education, 21(1),* 119-132.

Veldhuis, M., & van den Heuvel-Panhuizen, M. (2019). Supporting primary school teachers' classroom assessment in mathematics education: Effects on student achievement. *Mathematics Education Research Journal, 1-23*.

Waugh, C. K., & Gronlund, N. E. (2013). *Assessment of student achievement*. New York: Pearson.

Wild, P. J., McMahon, C., Darlington, M., Liu, S., & Culley, S. (2009). *A diary study of information needs and document usage in the engineering domain. Design Studies.* Retrieved from http://dx.doi.org/10.1016/j.destud.2009.06.002 accessed on 08 October 2021.

Yazan, B. (2015). Three approaches to Case Study methods in education: Yin, Merriam, and Stake. *The Qualitative Report, 20(2),* 134-152.

APPENDICES

Appendix A: The rubric for data collection (Adapted from DBE, 2011**)** (Research questions 1 and 2)

Question number in the examination paper		Cognitive levels				TOTAL MARKS	ACTUAL WEIGHTING %	CAPS WEIGHTING %
		Level 1	Level 2	Level 3	Level 4			25%
1	1.1 1.2							45%
2	2.1 2.2							20%
3	3.1 3.2							10%
Total:								

Appendix B: The data collection instrument (Research questions 3 and 4)

Question number in the examination paper		Content Areas					TOTAL MARKS	ACTUAL WEIGHTING %	CAPS WEIGHTING%
		NOR	PFA	SS(G)	M	DH			15%
1	1.1 1.2								35%
2	2.1 2.2								30%
3	3.1 3.2								10%
4	4.1 4.2								10%
Total:									

Appendix C: Permission letter to schools

The Principal
Xxx High School
Xxx Circuit

Dear Principal

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am an MEd student at the University of Pretoria and I am conducting a research study titled: ***Summative assessment in mathematics education: An analysis of Grade 9 mathematics school-based examination.*** The purpose of the study is to explore summative assessment in mathematics in order to determine the extent to which the examinations are aligned with the prescripts of the curriculum. This letter serves to request your permission to conduct the aforementioned research using the examination paper developed by and previously written at your school. Grade 9 mathematics examination papers as well as their memoranda will be used for analysis. The Circuit Manager has granted permission in this regard and I have attached the letter of permission.

If permission is granted, a pseudonym will be used to conceal the name of the school. I also would like to request your permission to use the data provided, 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 use of the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

For any additional information, you may contact me, George Manamela, at Xxx Xxx or my supervisor, Dr RD Sekao at Xxx or Xxx

Yours sincerely

George Manamela | Dr RD Sekao (Supervisor)

Dear Mr G. Manamela

LETTER OF CONSENT TO CONDUCT THE RESEARCH STUDY

I,…………………………………….., principal of …………………………………………, voluntarily and willingly permit Mr G. Manamela to conduct a research study titled: ***Summative assessment in mathematics education: An analysis of Grade 9 mathematics school-based examination***. I understand that the participation of the school in the afore-mentioned study to which I am consenting, will involve the analysis of Grade 9 mathematics examination question paper and its memorandum that are developed and administered at the school.

I declare that I understand the purpose of the study and that you (the researcher) subscribe to the ethical research principles, including the informed consent, privacy (confidentiality and anonymity) and trust.

In addition, I grant the University of Pretoria permission to use data provided 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 grant you permission to conduct your study in our school.

___________________________	________________	______________
(**Name** and **surname**)	Signature	Date

Appendix D: Examination from School A

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

GRADE 09

MATHEMATICS

NOVEMBER 2021

TEST

DUE DATE: NOVEMBER 2021

MARKS : 100

This question paper consists of 7 pages including the cover page.....

NOVEMBER 2021

INSTRUCTIONS AND INFORMATION

1. Write your name and class (for example grade 09^{A}) on your answer book.
2. This question paper consists of 2 SECTIONS.
   - **SECTION A** consist of THREE questions.
   - **SECTION B** consist of FOUR questions Answer ALL sections .
3. Number answers correctly according to the numbering system used in this question paper.
4. You may use a non-programable calculator.
5. The diagrams are not drawn to scale.
6. It is in your best interest to write neatly and legibly.

NOVEMBER 2021

SECTION A

- **QUESTION 1 [Whole numbers, integers]**
- **QUESTION 2 [EXPONENTS]**
- **QUESTION 3 [Patterns, functions and relationships]**

QUESTION 1

1.1 Sarah and Mpho have received a total of 15 000 **masks** to distribute in their community. The amount is divided into a ratio of **3:2** respectively. Find how many they will each have for distribution. (3)

1.2 Given the list of numbers : 0,42 ; π ; 36 ; 2 ; -48 ; $\sqrt{35}$ Write down the following :

1.2.1 Rational number (2)

1.2.2 Integers (2)

1.2.3 Multiple of 6 (1)

1.2.4 Prime number (1)

1.2.5 Irrationl Numbers (2)

1.3

Find the ***HCF*** of the following numbers using prime factorisation (*tree diagram)* (3)

1.3.1 32 AND 80

Find the ***LCM*** of the following numbers by listing their multiples. (2)

1.3.1 4, 6 AND 8

[16]

QUESTION 2

3.1 Simplify the following using **laws of exponents:**

$a^3 \times a^{-1} \div a^2$ (2)

$(x^3y)^4 \times 2x^3$ (3)

$\sqrt{25a^4c^8}$ (3)

3.2 Find the value of x: (3)

$3^{x+2} = 27$

[11]

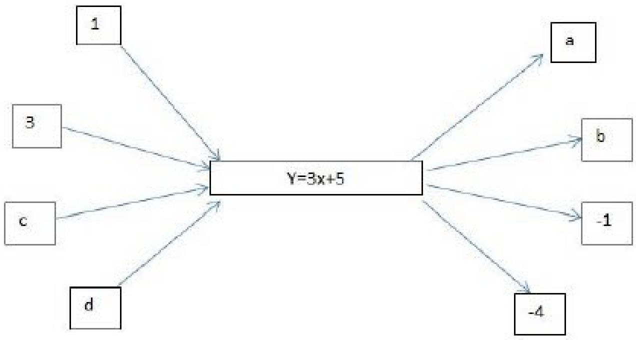
NOVEMBER 2021

QUESTION 3

3.1 Consider the sequence **6;11;16; 21;........**

3.1.1 Write down the next two terms. (2)
3.1.2 Determine the general rule (nth term). (3)
3.1.3 Calculate the 15th term. (2)

3.2 Determine the values of ***a, b, c, and d.*** (4)



3.3 Given the table:

Position in the sequence	1	2	3	4	5	**g**	Tn
Term	1	8	15	**e**	**f**	57	.....

3.3.1. Determine the values of ***e, f and g*** (3)

3.3.1 Determine the general rule of the pattern in the form, $Tn =$ (2)

[18]

TOTAL SECTION A [45]

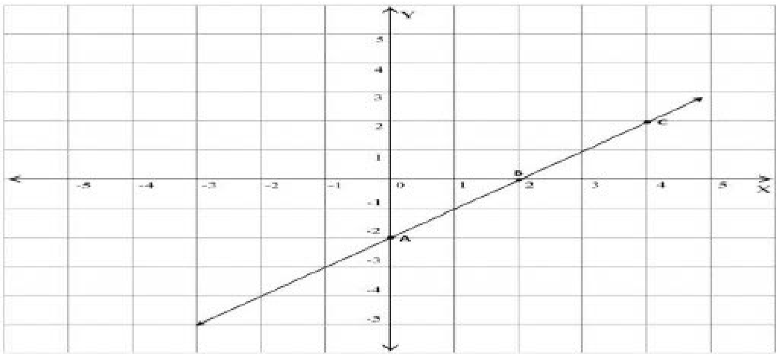
NOVEMBER 2021

SECTION B [55]

- **QUESTION 4 [Graphs and transformation]**
- **QUESTION 5 [ALGEBRAIC EXPRESSIONS]**
- **QUESTION 6 [ALGEBRAIC EQUATIONS]**
- **QUESTION 7 [Geometry of straight lines and Geometry of 2D]**

QUESTION 4

4.1 Write down the coordinates of the following points. (3)



4.2 Given: $\boldsymbol{y = 4x - 3}$ complete the table below and on the same set of axes plot the graphs (*USING THE GRAPH SHEET*). (6)

x	-3	-2	-1	0	1	2	3
$y = 4x - 3$							

[9]

QUESTION 5

5.1 GIVEN: $14p^4 - 2p^3 + 8p - 6$

5.1.1 How many terms does the expression have? (1)

5.1.2 Calculate the value of the expression if $p = 1$ (2)

5.2 Simplify: (3)

$12xc + 3c + 10c - 4ax - x^2 + 2xc + 11xa + 8x^2$

5.3 Expand each of these expressions:

5.3.1 $(a + b)(a + b)$ (2)

5.3.1 $(2a - 3b)(2a - 3b)$ (2)

5.4 Divide the following :

NOVEMBER 2021

5.4.1 $\frac{18x^2+4x}{2x}$ (2)

5.4.2 $\frac{3x(5x+4)+6x(5x+3)}{5x}$ (3)

[15]

QUESTION 6

6.1 If $\frac{a+3}{b}=\frac{5}{6}$;Determine b when $a=5$ (3)

6.2 Solve the following equations:

6.2.1 $3y+22=15$ (2)

6.2.2 $x^2+5x-4=0$ (3)

6.3 Ben and Thabo decide to do some calculations with a certain number. Ben multiplies the number by 5 and adds 12. Thabo gets the same answer as Ben when he multiplies the number by 9 and subtracts 16. What is the number they worked with? (3)

[11]

QUESTION 7

7.1 The following box has possible answers to complete the sentences below.

Square, Scalene, 45° , Parallelogram , 60° , kite, Revolution, Isosceles, 90°, Compliment.

1.1.1 A triangle with no equal sides is called a ____________ (1)

1.1.2 In a right-angled isosceles triangle the sizes of the angles are ______ , ______ and __________ (3)

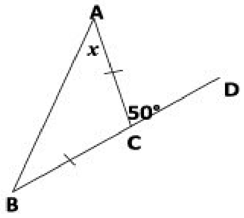
1.1.3 60º is the____________ of 30º (1)

1.1.4 Each interior angle of an equilateral triaangle is ____________ (1)

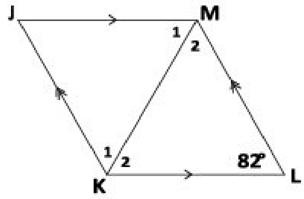
NOVEMBER 2021

7.2 BCD is a straight-line segment. (3)

Find the size of x.



7.3 JKLM is a rhombus. Calculate with reasons the sizes of the following angles:

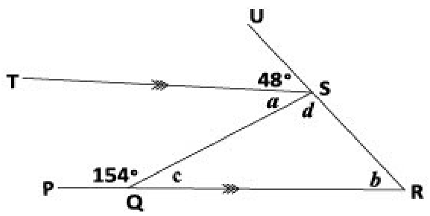


7.3.1 $\angle KJM$ (2)

7.3.2 $\angle M_2$ (3)

7.4 Calculate the sizes of a, b, c and d

(6)



[20]

TOTAL SECTION B [55]

TOTAL MARK [100]

"mathematics is the cheapest science. Unlike physics or chemistry, it does not require an expensive equipment. All one needs for mathematics is a pencil and paper" – George Polya.

Appendix E: Examination from School B

LIMPOPO

PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

TERM 4 TEST

GRADE 09

MATHEMATICS
17 NOV 2021

MARKS: 100

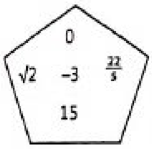
TIME: 2 HOUR

INSTRUCTIONS TO THE CANDIDATES

1. This question paper consists of 8 questions
2. Answer ALL questions.
3. Clearly show all the calculations
4. Write neatly and legibly.
5. The use of scientific calculator is allowed
6. This question paper consist of 4 pages

Question 1

a. From the set of numbers given, identify the following:



- **i.** natural numbers
- **ii.** integers
- **iii.** irrational numbers (3)

b. Convert these decimals to fractions.

i. 0,25 **ii.** 0,3 **iii.** 1,65 (3)

c. Evaluate the following:

i. $\sqrt{64} - \sqrt{81}$ **ii.** $60 \div \frac{1}{3}$ **iii.** $\sqrt{6,25} + 7\frac{1}{2}$ (3)

d. Round off 245 837,218 to the nearest

i. Hundred **ii.** Hundredth (2 decimal places) (2)

e. Solve the following word problems

- **i.** A woman travels 740 km in 6 hours 24 min. What was her average speed for the journey? (3)
- **ii.** A man saves R3 200 in the bank for 5 years. If the bank offers him 5,5% interest per year, how much will he have altogether after 5 years. Calculate the interest using the compound interest formula $A = P(1 + i)^n$. (3)
- **iii.** If the current exchange rate is \$1 = R9,45, convert \$28 to Rand. (2)
- **iv.** If the manager of a shop offers a 20% discount to staff, how much would a staff member have to pay for an item marked R685,95? (3) [22]

Question 2

Simplify the following:

a. $\dfrac{16x^3y^2}{24x^5y^{-3}}$ (2) **b.** $3x(2x^2 - 4x + 2)$ (2)

c. $(2x + 3)(2x - 3)$ (2) **d.** $(5x - 1)^2$ (3)

e. $\frac{4x}{3} - \frac{2x}{5}$ (3)

[12]

Question 3

Factorise the following if possible:

a. $2xy^2 - 12y$ (2)

b. $3x(a - 2b) + 4y(2b - a)$ (3)

c. $4a^2 - 25b^2$ (2)

d. $x^8 - 16$ (4)

[11]

Question 4

Solve the following equations:

a. $2 - 5x = 3x - 14$ (2)

b. $5(x + 3) + 9 = 3(x - 2) + 6$ (2)

c. $\frac{x+1}{2} - 4 = \frac{x-1}{4}$ (3)

d. $(x - 4)(x + 7) = 0$ (2)

e. $4x^2 - 8x = 0$ (2)

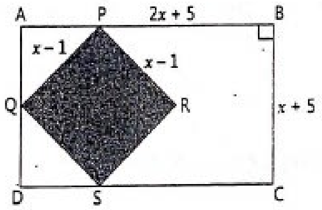
f. $x^3 = -\frac{1}{27}$ (2)

g. $2^{2x+1} = 8$ (3)

[16]

Question 5

1. Consider the diagram below when answering the questions that follow:

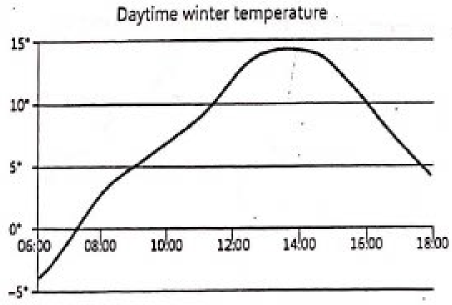


a. Find the area of rectangle ABCD. (2)

b. Find the area of square PQRS. (2)

c. Find the area of the unshaded region. (3)

2. Look at this graph and answer the questions.



a. Describe the type of day that this temperature graph shows us. (1)

b. What is the maximum temperature for the day? (1)

c. What is the minimum temperature as indicated on the graph? (1)

d. When is the temperature 10°C? (Careful there are two answers) (2)

3. Consider the equations $y = 3x - 1$

a. Write down the y-intercept. (1)

b. Write down the x-intercept. (2)

c. Sketch the graph. (3)

d. On the same set of axes sketch the graph of $y = 2$. (2)

e. Write down the co-ordinates of the point of intersection of the graphs. (1)

4. Write the equation for a straight line with gradient $= -3$ and y-intercept (0;2) (1)

[22]

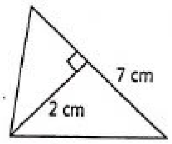
Question 6

a. In the following number pattern 2; 5; 8; 11… write the next 3 terms and give the rule for the number pattern. (2)

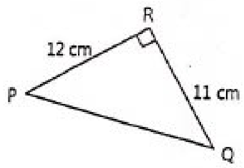
b. Given $p = 2q + 7$, find values for p if: i. $q = -3$ (2) ii. $q = \frac{7}{2}$ (2)

c. Calculate the area of each of the following shapes.

i. (2)



d. Calculate the length of side PQ of the right angled triangle PQR. (3)

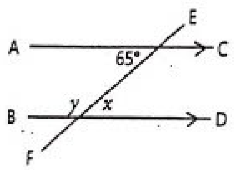


[9]

Question 7

Find the unknown in each of the following with reasons:

a. (4)



[4]

Question 8

Write down the co-ordinates for the image after the following translations:

a. P(−3 ; −6) $(x; y) \rightarrow (x; -y)$

b. Q(0 ; 5) $(x; y) \rightarrow (y; x)$

c. R(−4 ; 3) $(x; y) \rightarrow (-x; y)$

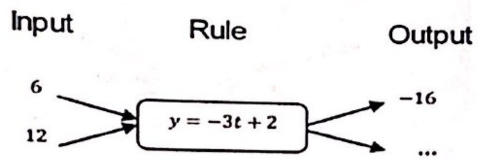
d. V(3 ; −5) if it is reflected about the x-axis [4]

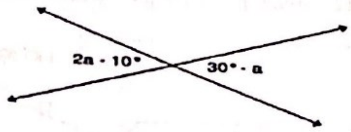
TOTAL [100]

Appendix F: Examination from School C

[redacted] **QUESTION 1**

1.	MULTIPLE CHOICE QUESTIONS		
	Example 1.11. B		
	1.1	$(a+b)^0 =?$ A. $a+b$ B. 2 C. 1 D. 0	(1)
	1.2	The highest common factor of 18, 30, and 48 is? A. 3 B. 4 C. 6 D. 8	(1)
	1.3	Complete the following 2000 ml = ……………….L of liquid. A. 1L B. 2L C. 3L D. 20L	(1)
	1.4	The sum of interior angles of a quadrilateral is? A. 180° B. 360° C. 90° D. 270°	(1)

	1.5	Complete the flow diagram by using given rule  A. -18 B. -34 C. -36 D. -38	(1)
	1.6	If two straight lines are parallel, then the… A. Product of the gradients is -1. B. Gradients are equal. C. Product of the gradients is 1. D. Sum of the gradients is 0.	(1)
	1.7	$4{,}8 - 2{,}042 =$……….. A. 2,38 B. 2,420 C. 2,756 D. 2,750	(1)
	1.8	$x^2 \times x^3 =$……….? A. x^2 B. x^1 C. x^5 D. x^6	(1)

	1.9	Find the value of a.  A. $13,3^{\circ}$ B. 15° C. 40° D. 10°	(1)
	1.10	$(2x-3)(x+4)=$...............? A. $2x^2+5x-12$ B. $2x^2-5x+12$ C. $2x^2-3x+12$ D. $2x^2-3x+12$	(1)
			MARKS:[10]

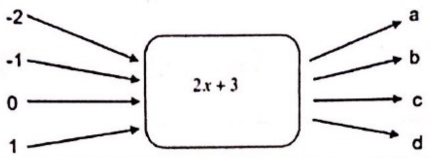
QUESTION 2

2.1	Express each percentage as a fraction and simplify where possible:- A. 64% B. $9\frac{3}{8}\%$ C. 0,4%	 (1) (2) (1)
2.2	What fraction is : A. 450 mm of 8 m.	(2)
		MARKS:[6]

PLEASE TURN OVER

QUESTION 3

3 Study the flow diagram below and answer questions that follows:



3.1. Determine the numerical values of the output values a, b, c and d . Write the values in the table below. (4)

x	-2	-1	0	1
$y = 2x + 3$	a	b	c	d

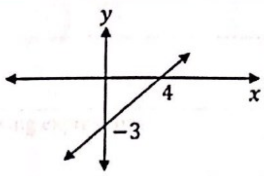
3.2. State the rule in words (2)

3.3. Determine the ordered pairs of numbers. (2)

MARKS:[8]

QUESTION 4

4.1 Given the straight-line graph below:



4.1 Determine the gradient. (1)

4.2 Determine the equation of the given straight-line graph. Use $y = mx + c$ (2)

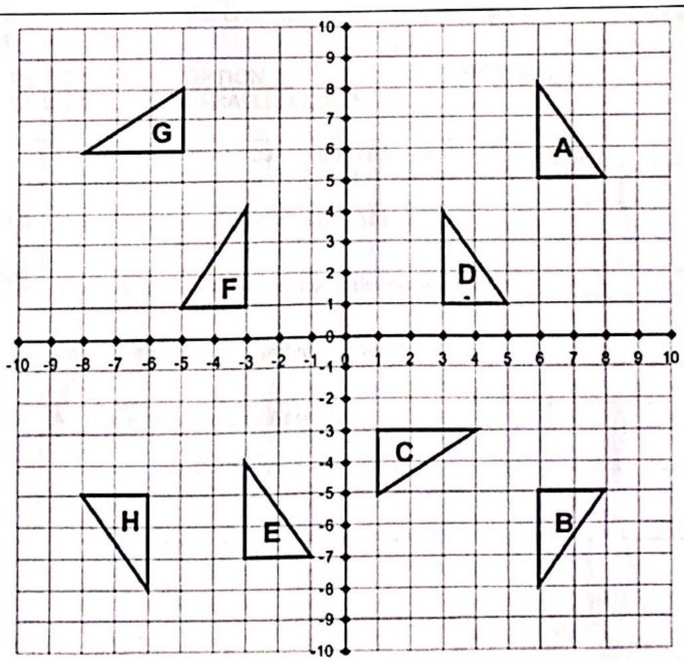
4.2	Given the equation $y = 2x - 2$, then answer the following:		
	4.2.1	Calculate the value of x.	(2)
	4.2.2	Calculate the value of y.	(1)
	4.2.3	Draw the graph of $y = 2x - 2$.	(3)
			MARKS:[9]

QUESTION 5

5.1	Solve the following equations:-		
	5.1.1	$2x - 7 = 15$	(2)
	5.1.2	$x^2 - 2x - 3 = 0$	(3)
	5.1.3	$2^x = 8$	(2)
	5.1.4	$8 = \frac{4}{x}$	(2)
	5.1.5	$5(x-1) - (1-2x) = 8$	(4)
5.2	Simplify each of the following expressions:-		
	5.2.1	$3m - n + 6n - 5m$	(2)
	5.2.2	$\frac{b^3 + 18b^2 - 15b}{3b}$	(3)

5.3	Factorize each of the following:-		
	5.3.1	$m^2 - n^2$	(2)
	5.3.2	$a^2 + 4a + 4$	(2)
	5.3.3	$x^2 - 6x + 9$	(2)
			MARKS:[24]

QUESTION 6

6.	Study the figure and answer the following:
	

	6.1	Use the graph to fill up the table: | From | To | Describe transformation | | A | B | | | D | | Translation 3 units right and 4 units up | | F | | Reflection over the y-axis | | A | G | |	(4)
	6.2	Enlarge triangle D by the scale factor of 2, through the origin. Label your new triangle D'. Answer on the graph paper provided.	(2)
			[6]

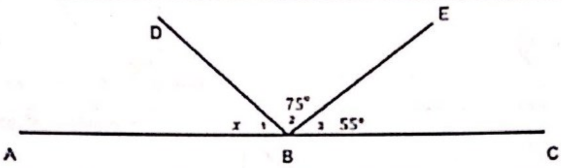
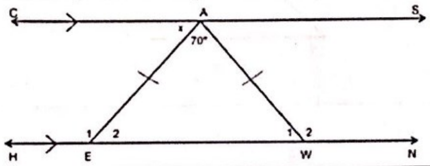
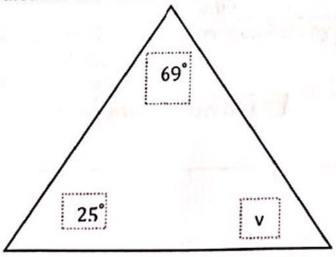
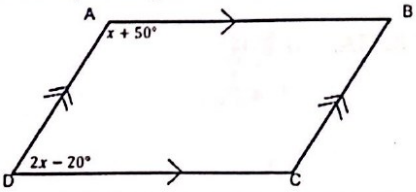
From	To	Describe transformation
A	B	
D		Translation 3 units right and 4 units up
F		Reflection over the y-axis
A	G	

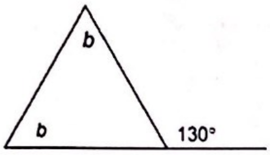
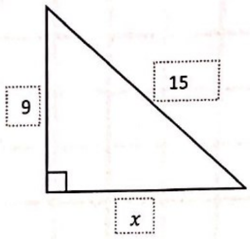
QUESTION 7

7	Classification of 2D shapes. For each of the statements below select the option that is true by writing the letter that corresponds to the correct answer in the space provided. **Example 5.6.B** **OPTION A:** SQUARE **OPTION B:** PARALLELOGRAM **OPTION C:** KITE **OPTION D:** TRAPEZIUM		
	7.1	Shape has 2 pairs of parallel sides and corners of 90°. Answer:_________	(1)
	7.2	Shape has 1 pair of parallel sides. Answer:___________	(1)
	7.3	Shape has one pair of opposite angles equal. Answer:_______________	(1)
	7.4	Only one diagonal is bisected. Answer:_______	(1)
	7.5	All four sides are equal. Answer:__________	(1)
			[5]

PLEASE TURN OVER

QUESTION 8

8.1	In the figure below, ABC is a straight-line, $\widehat{B_2} = 75^\circ$ and $\widehat{B_3} = 55^\circ$.	
		
	8.1.1 Determine with reason the size of angle x.	(2)
8.2	In the figure below, CS//HN , $E\hat{A}W = 70^\circ, AE = AW\ AND\ C\hat{A}E = x$ 	
	8.2.1 Give a reason why $\widehat{E_2} = x$.	(1)
	8.2.2 Hence, determine the value of x.	(3)
8.3	Calculate the value of v 	(3)
8.4	ABCD is a parallelogram. Calculate the size of $\hat{B}$. 	(4)

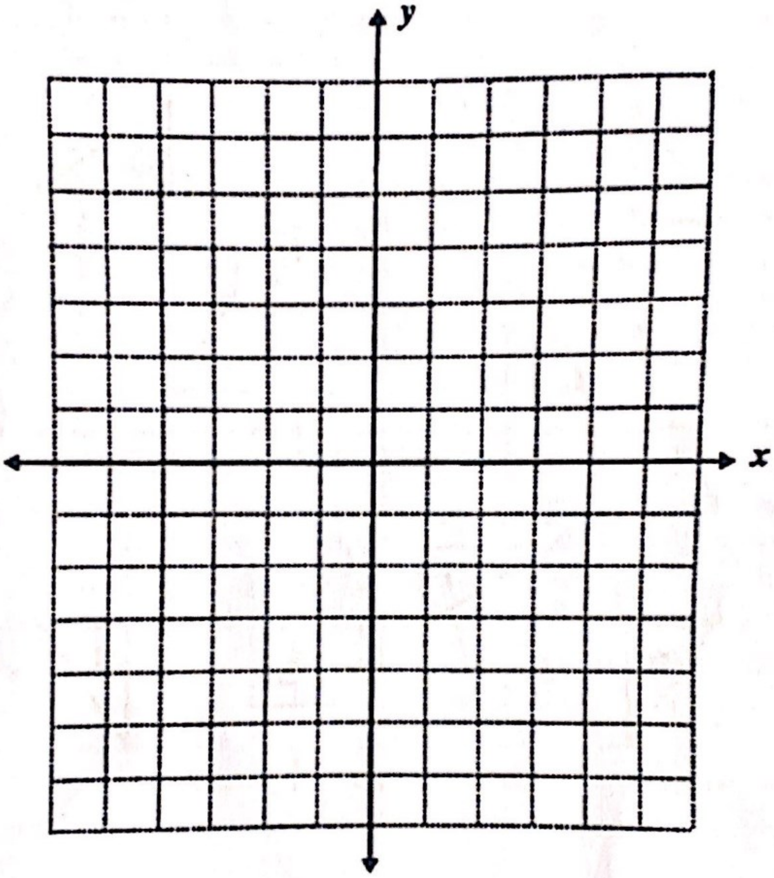
8.4	Calculate the size of $\hat{b}$. 	(3)
8.6	Calculate the value of x. 	(3)
		[19]
	QUESTION 9	
9.1	Find the LCM for the given numbers by prime factors I. 52 and 78 II. 24, 36 and 60	(2) (3)
9.2	Find the HCF for the given numbers by using prime factorization I. 52 and 78 II. 27, 36, and 90	(2) (3)
9.3	What are the prime factors of 1728	(3)
		MARKS:[13]

TOTAL MARKS:[100]

PLEASE TURN OVER

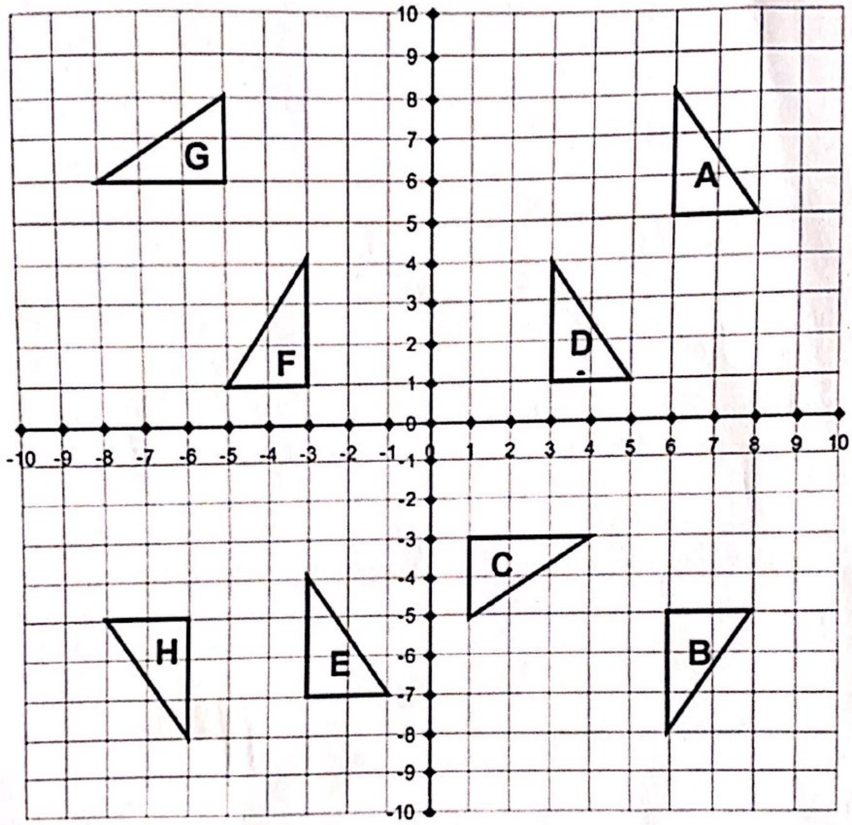
Learner's name:____________________________ Grade 9

4.2.3



Learner's name:_________________________________ Grade 9

6.2



PLEASE TURN OVER