UNIVERSITEIT VAN PRETORIA
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YUNIBESITHI YA PRETORIA

THE RELATIONSHIP BETWEEN PARENTAL EXPECTATIONS AND GRADE 5 NUMERACY ACHIEVEMENT

by

LAST SINANDAWA

17253005

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UNIVERSITY OF PRETORIA

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Declaration

I, LAST SINANDAWA, student number 17253005, do hereby declare that the dissertation/thesis with the title: *The relationship between parental expectations and grade 5 numeracy achievement*, which I hereby submit for the degree M.Ed. in Assessment and Quality Assurance in Education and Training, at the University of Pretoria, is my original work and has not previously been submitted by any other person for a degree at this or any other tertiary institution.

LAST SINANDAWA (signed 30 September 2021)

Ethical Clearance Certificate

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Faculty of Education

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Abstract

The relationship between parental attitudes, beliefs and expectations (ABE) on the mathematics achievement of Grade 5 learners in South Africa was investigated in this study while accounting for background factors. The current study analysed data from the Trends in International Mathematics and Science Study (TIMSS Numeracy 2015). A total of 10 932 learners and 10 493 parents participated in the study in South Africa. At the time, a two-stage stratified sampling design was used to select a nationally representative sample. The participants answered questionnaires, and the learners wrote a mathematics assessment.

This study takes the form of a secondary analysis. Descriptive statistics and linear multiple regression analysis were used to assess the degree to which parental ABE is related to mathematics achievement. The results of the study showed that there was no discernible relationship between parental attitudes and mathematics achievement. There was also no relationship between parental homework involvement and learner achievement in mathematics. However, some relationship was found between mathematics achievement and parental expectations. Other background factors which showed a relationship with mathematics achievement were socio-economic status, how often a child spoke the language of the test, provision of private tutors and the early numeracy activities done by the child before going to school.

Key words: Parental attitudes, beliefs and expectations (ABE), mathematics achievement, TIMSS Numeracy, variables, homework, parental involvement, linear multiple regression analysis.

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List of abbreviations

HSRC	Human Sciences Research Council
IEA	International Association for the Evaluation of Educational Achievement
IRT	Item Response Theory
LoLT	Language of Learning and Teaching
NRC	National Research Coordinator
PV	Plausible Value
SES	Socio-Economic Status
SACMEQ	Southern and Eastern African Consortium for Monitoring Educational Quality
SMIRC	Science and Mathematics Item Review Committee
SPSS	Statistical Package for Social Science
PIRLS	Progress in International Reading and Literacy Study
TIMSS	Trends in International Mathematics and Science Study

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Chapter 1
Introduction

1.1 Introduction to the Research

Despite various policies and measures by the Department of Basic Education and other education stakeholders like civic organisations, South African learners have performed relatively poorly compared to learners from other countries in international large-scale assessments (Reddy et al., 2015; Spaull, 2013; Van der Berg et al., 2016). According to Spaull (2013), what is worrying is that despite the huge amounts of money being put into education, South African learners are outperformed by learners from many low-income African countries in mathematics. For example, South African Grade 6 learners participated in the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) assessment in 2007, and South Africa ranked 8th out of the 14 regional education structures in mathematics, behind much poorer countries like Tanzania, Swaziland, Zimbabwe and Kenya (Spaull, 2013). SACMEQ is a cross-national initiative by countries in southern and Eastern Africa to test the numeracy and literacy skills of Grade 6 learners in their respective countries (van der Berg, 2008). In all the iterations of the Trends in International Mathematics and Science Study (TIMSS) that South Africa participated in, it was consistently one of the worst-performing countries, which points to the existence of huge problems in mathematics (Reddy et al., 2015; Spaull & Kotze, 2015). TIMSS is an international assessment focusing on assessing learners' knowledge and understanding of mathematics and science at Grade 4 and Grade 8 levels (Reddy & Hannan, 2018).

Even though South Africa made some significant improvement in learners' achievement between TIMSS 2002 and TIMSS 2011, it is still the worst-performing country among the middle-income countries even after the improvement (Spaull, 2013). When South Africa participated in the TIMSS 2011 assessment, its Grade 9 learners were found to be, on average, two years behind the Grade 8 learners of the other middle-income countries in mathematics (Spaull, 2013). According to the TIMSS (2011) report, only a quarter of South African learners who participated in the 2011 TIMSS study managed to score above the minimum benchmark of 400, a score depicting the lowest level of competence (Reddy et al., 2015). This result means that 75% of the South African learners who took part in the 2011 TIMSS study were not competent in mathematics. The 2015 TIMSS report found that at the Grade 5 level, South Africa ranked 47th out of 48 countries for mathematics, making it one of the worst-performing countries (Visser et al., 2015). The TIMSS study of 2015 attributed the low performance of South African learners for mathematics in Grade 5 to factors at home, school and the community environments. When parental perceptions of mathematics are negative, South African mathematics learners have a high probability of poor performance (Visser et al., 2015).

Learners' achievement in mathematics is influenced by many factors, including the educator, the school environment, and the socio-economic status (SES) of learners (Visser et al., 2015). Some factors include the educators' ability to offer meaningful lessons that positively impact learner performance and parental involvement in learners' education (Arends et al., 2017; Reddy et al., 2015). Parents are one of the most important factors that influence learners' performance in education (Soni & Kumari, 2015; Visser et al., 2015). Learners are most likely to listen to what their parents tell them and value what their parents value. If the mother views mathematics as important, the child will also likely do the same (Howie, 2004).

The attitudes, beliefs and expectations (ABE) that parents hold about mathematics are likely to be influenced by their contexts and environments of varying socio-economic status. An understanding of these different backgrounds can help to explore further the link between their ABE and mathematics achievement by their children. The study will focus on parental attitudes, beliefs, and expectations (ABE) and how they relate to mathematics achievement.

1.2 Background to the research problem

"Neglect of mathematics works injury to all knowledge, since he who is ignorant of it cannot know the other sciences or the things of this world". Rodger Bacon (1214-1294).

Mathematics is an important subject because it is a prerequisite for many courses at the tertiary level, among them commerce, actuarial science, engineering, information technology and medicine (Juan & Visser, 2017; Soni & Kumari, 2015). The knowledge of mathematics is also crucial in life because it teaches general life problem solving (Legner, 2013; Mbugua et al., 2012). Mathematics also help in logical thinking and reasoning and understanding abstract statements (Legner, 2013). The fourth industrial revolution (rapid technological advances) necessitates that the skills required by industry are evolving. For this reason, education models and methods should evolve as well because the "traditional" business models will soon cease to exist (Leopold et al., 2017; Shay, 2020; Visser et al., 2015). This development means that businesses and policymakers will have to respond appropriately to the changing marketplace.

In light of technological advances, learners must be equipped with skills and knowledge that are relevant locally and globally by concentrating on core skills and competencies like mathematics that will remain relevant, irrespective of how the global landscape evolves (Kemp, 2016; Shay, 2020). Broad literature suggests that a core component of the curriculum should be characterised by science, technology, engineering and mathematics (STEM) to build a pipeline for future talents (Hodaňová & Nocar, 2016; Jojo, 2019; Mbugua et al., 2012; Ramohapi et al., 2015). As the TIMSS report of 2015 shows, many factors influence learner achievement in mathematics. Many mathematics teachers in South Africa, especially in rural areas, have significantly lower levels of content knowledge, making it difficult to improve learner achievement (Spaull, 2013). The quality of the mathematics teachers is directly related to learner achievement (Mji & Makgato, 2006; Ramohapi et al., 2015; Spaull, 2013). Furthermore, very few learners seem to be confident in mathematics leading to poor performance. The problem of confidence was found to be linked to early childhood at home and in the community (Reddy et al., 2016). Visser et al. (2015) argue that bullying can also affect learner performance as boys performed relatively poorly compared to girls.

Parents play an important role in the educational performance of learners. It is worthwhile to interrogate the role that parents play in the learning of their children to find ways to improve South African learners' mathematics achievement.

1.3 Statement of the problem

The TIMSS report of 2015 coincided with a decline of 20% in the mathematics pass rate of Grade 12 learners who sat for their exams the previous year (Visser et al., 2015). Moreover, fewer learners have been taking mathematics and science, with 75 000 fewer matrics writing these exams in 2017 than in 2016 (Leopold et al., 2017). According to Shay (2020), the decline in mathematics is twofold, namely the decline in the number of learners taking mathematics as a subject and their performance. Fifty-four per cent (54%) of learners who wrote their Grade 12 examinations in 2019 passed mathematics, a four per cent decline from 58% in 2019 (Shay, 2020). Several factors have to be considered to improve this worrying low-performance trend in mathematics in South Africa. For purposes of this study, the researcher will, however, study the influence[1] of parental attitudes, beliefs, and expectations on mathematics and its possible influence on learner achievement.

Parental involvement has been shown to positively impact learner performance (Jay et al., 2018; Muchuchuti, 2015). If parents collaborate with school authorities, both the physical and academic performance of the learners improve (Llamas & Tuazon, 2016). Llamas and Tuazon (2016) add that learners whose parents are involved are active and ready to learn. They learn to be punctual from a young age; they also learn to be persistent as the parents continuously inquire about their progress, and they do not want to disappoint them.

[1] Note that 'influence' does not imply that this study will look at causality. Rather, the aim is to establish statistically significant relationships.

Moreover, when parents get involved earlier in a child's educational processes, the more influential the effects; and the most effective forms of parental involvement are those which engage parents in working directly with their children on learning activities at home (Sapungan & Sapungan, 2014). Similarly, if parents create a home environment that encourages learning and expresses high but realistic expectations of their children's achievement and future careers, learners improve their performance (Yamamoto & Holloway, 2010).

It is widely accepted that learning of any sort starts at home. Parents and other members of the family are the primary educators of children. They are the ones who lay down the foundations for learning that is social, intellectual and cultural (Howie, 2004; Jay et al., 2018; Levi, 2011; Meier & Lemmer, 2015; Soni & Kumari, 2015; Uscianowski, 2018; Yamamoto & Holloway, 2010). Children will tend to value what their parents value and hold similar beliefs to their parents. Parents may participate in school-initiated activities like helping with homework and attending school meetings (Jay et al., 2018; Uscianowski, 2018). Parents may also help encourage learners to work harder and aim higher in mathematics and set high expectations for them (Mutodi & Ngirande, 2014).

It appears that parents' attitudes and beliefs towards mathematics have a significant influence on learner performance (Mohr-Schroeder et al., 2017; Soni & Kumari, 2015). The problem is that the impact of parents' ABE towards mathematics and the performance of South African mathematics learners is not fully known; therefore, interventionist initiatives are not implemented to ensure that these parental credentials are considered for the benefit of the South African mathematics learners.

Using the TIMSS Numeracy 2015[2] data, the relationship between parents' perceived importance of mathematics, exhibited through their attitudes, beliefs, and expectations towards the subject and learner achievement can be investigated. This approach could help policymakers implement processes inclusive of parents, which can benefit mathematics learners. Programmes aimed at changing parental attitudes, beliefs and expectations can be initiated to the benefit of the learners.

1.4 Research Questions

The primary research question for this study is:

What is the relationship between parental attitudes, beliefs, and expectations regarding the importance of mathematics and South African Grade 5 learner achievement?

[2] This study used TIMSS Numeracy 2015 data because at the time the topic was conceptualised in 2019, TIMSS data from the 2019 cycle had not been available yet.

The primary research question can be answered by exploring the following sub-research questions:

- To what extent is parental encouragement and home discussions related to learner achievement in mathematics?
- To what extent is homework involvement and provision of private tutoring related to learner achievement in mathematics?
- Which other parental factors and background variables (in terms of availability of resources, early literacy and numeracy activities before the child goes to school, gender of learner, language of testing and frequency with which the language of testing is used at home) have a positive or negative relationship with learner achievement?

1.5 Objectives of the study

- To investigate the relationship between parental ABE towards mathematics and achievement for Grade 5 learners in South Africa.
- To examine if parental involvement in learners' work through home discussions and homework could improve mathematics achievement.
- To find out what other parental factors and background variables might be related to mathematics achievement.

1.6 Nature of the study

The study dealt with in this dissertation is a Secondary Data Analysis (SDA) project related to the TIMSS 2015 results of Grade 5 South African learners. TIMSS is an international study that assesses learners in mathematics and science in the participating countries. Scores on the parent questionnaires and learner mathematics achievement tests were analysed empirically. Quantitative methods (statistics) were used to determine the relationship between parent perceptions of mathematics and learner achievement in mathematics, using the TIMSS Numeracy 2015 data set.

The paradigm guiding this study is post-positivism. Since the data had already been collected by TIMSS, the chances of both sample and measurement bias are greatly minimised. TIMSS is a large-scale study that adheres to the highest standards of sampling techniques and data collection and measurement.

1.7 Concept Clarification

Parent: The parent is an adult who is the child's primary caretaker and could be a biological parent, legal guardian(s) or a member of the extended family.

Academic achievement: This is the outcome of the learning process provided to learners in schools, determined by the marks or grades they secure in the examinations (Islam & Khan, 2017).

Socio-Economic Status (SES): This status determines an individual and family's comparative position in society regarding income, political power, level of education and occupational prestige (Islam & Khan, 2017).

Parental attitudes: These are positive or negative feelings that parents hold towards something which influences them to either like or dislike it.

Parental beliefs: These are fixed ideas that parents have about how their own children learn and develop (Sonnenschein et al., 1997).

Parental expectations: Parental expectations are beliefs or judgements that parents or guardians hold about their children's future achievements (Yamamoto & Holloway, 2010).

1.8 Purpose of the study

The study reported in this dissertation sought to establish the possible relationship between parental attitudes, beliefs and expectations on the mathematics achievement of Grade 5 learners. The study aimed to identify some types of parental involvement that might be positively associated with mathematics achievement when accounting for background variables. Learner performance in South Africa has been consistently poor; therefore, different approaches need to be considered to help improve learner mathematics achievement.

The information from this study might help inform policy on the level of parental involvement in their children's mathematics education. This evidence might persuade the policymakers to enact policies leading to awareness among parents about the key roles they can play to help their children to develop a positive attitude towards mathematics, consequently leading to better achievement. If a link is found between parental ABE towards mathematics and learner achievement, the parents can be involved more with their children's studies, especially in the context of the fourth industrial revolution.

1.9 Assumptions

The researcher made the following assumptions:

- The TIMSS Numeracy 2015 data for Grade 5 learners' performance indicates mathematics knowledge and attainment.
- The data was collected ethically, and also that validity and reliability were considered and ensured in the data collection.

- Responses from parents involved in the TIMSS Numeracy 2015 study reflect the home environment and indicate parental involvement.

1.10 Delimitations

The study only focused on the relationship between the achievement of South African Grade 5 learners that participated in TIMSS Numeracy 2015 and the parental attitudes, beliefs and expectations towards mathematics. Although there are several parental factors that may be associated with learner achievement in mathematics, the focus was only on those factors that may be classified as parental involvement measured by TIMSS Numeracy 2015.

1.11 Ethical Considerations

The ethical clearance process of the University of Pretoria was adhered to, and ethical approval for the study was obtained from the Faculty of Education's Ethics Committee. Additionally, ethical clearance was obtained from the Human Science Research Council (HSRC) before data was collected. Since the study was a secondary data analysis, issues of confidentiality were ensured as only broad findings were outlined, and the data contains no identifying information about schools, teachers, learners or parents.

1.12 Structure of Dissertation

The remaining chapters in this dissertation are organised as follows:

Chapter 2: Background to the TIMSS Numeracy 2015 study

In Chapter 2, a description of the background to the TIMSS Numeracy 2015 study is made in terms of the history of the International Association for the Evaluation of Educational Achievement (IEA). The methodology used for TIMSS Numeracy 2015 is explained in terms of sampling methods used, development of instruments as well as how the test was administered.

Chapter 3: Literature Review and Conceptual Framework

In Chapter 3, similar studies are reviewed to situate the study into the broader field that has some related studies. Chapter 3 looks at what other scholars have written on the topic or a related topic, emphasising the studies conducted and the results obtained. The conceptual framework is also described, which helps determine the variables to be investigated in this study.

Chapter 4: Methodology

This chapter describes the theoretical approaches and the methodology followed in this study in terms of the participants, the instruments used, and the data analysis methods utilised.

Chapter 5: Results

Chapter 5 presents the results in terms of any relationships between selected variables and mathematics achievement. The results are also discussed in terms of possible recommendations based on the evidence presented in the current study.

Chapter 6: Conclusions and recommendations

Chapter 6 provides a summary of the study and the conclusions and recommendations drawn from the findings in the study. The chapter also presents the limitations of the study and a pointer on areas for future studies.

1.13 Summary

South African learners have fared poorly in mathematics both in national assessments and international assessments. Even though South Africa spends considerably more money in real terms than other sub-Saharan countries, South African learners are still outperformed by many learners from the poorer African countries in mathematics. Though South Africa has made some discernible improvement in TIMSS assessments over the years, the achievement of its learners in mathematics remains the lowest of all middle-income countries. This poor achievement by South African learners is notwithstanding the fact that South Africa administers TIMSS to a cohort of learners who are one grade above the international norm. The number of learners taking mathematics as a subject and the national average pass-rate for mathematics for learners in the Grade 12 exit examination has been decreasing. This poor performance of learners in mathematics is a huge concern since mathematics is considered the pivot in the study of STEM subjects. If something is not done to rectify this worrying trend of South African learners' poor achievement in mathematics, then it is likely that South Africa will keep having a skills shortage in the critical STEM field.

This chapter served as an introduction to the role that parents can play to help their children achieve better in mathematics. Parental attitudes towards mathematics may act as a pathway to the children's attitudes towards mathematics. This study seeks to find out if there exists any relationship between parental attitudes towards mathematics and the achievement of Grade 5 learners in mathematics. The study is a secondary data analysis of the TIMSS Numeracy 2015 data in which South African Grade 5 learners participated.

If parental attitudes are found to be aligned to mathematics achievement, then recommendations may be made to the government and other organisations with an interest in education to roll out programmes that target changing the attitudes of parents towards mathematics.

Chapter 2

Background to the TIMSS Numeracy 2015 Assessment

2.1 Introduction

This chapter provides an outline of the TIMSS assessment and its history. The chapter commences by looking at the International Association for the Evaluation of Educational Achievement (IEA), the parent organisation of TIMSS. A brief history of TIMSS in South Africa is also given, followed by the background to TIMSS Numeracy 2015 assessment. TIMSS Numeracy 2015 Research Design and Methodology is explained in detail for the remainder of the topic.

2.2 The International Association for the Evaluation of Educational Achievement (IEA)

The IEA is an independent international grouping of national research institutions, government research agencies, scholars and analysts aiming to conduct large-scale empirical comparative education studies of educational achievement. It also measures other factors related to education such as family background, school level contexts and learner characteristics (IEA, 2017a, Mullis & Martin, 2013; Neuschmidt, 2019). According to Neuschmidt (2019), the primary aim or mission of the IEA is:

- To provide the basis for international comparison of educational systems, which will aid policymakers to assess the health of their educational systems in terms of strengths and weaknesses;
- To provide reliable data which will enhance policymakers' understanding of the myriad of factors (school and non-school) that affect teaching and learning;
- To provide high-quality data that will enable the identification of areas of weakness and action and prepare and evaluate educational reforms;
- To assist national education systems in developing national strategies to improve and monitor the implementation of those strategies; and
- To make a global contribution to the development of a network of researchers in educational assessments and evaluation.

The origin of the IEA dates back to 1958, with the founders preoccupied with finding ways to deal with problems of school and learner evaluation (IEA, 2017b; Neuschmidt, 2019). The IEA focuses on subjects of particular interest to the participating countries. The subjects that South Africa participate in are mathematics and science.

TIMSS and the Progress in International Reading Literacy Study (PIRLS) are the two flagship international studies the IEA conducts at regular intervals, i.e. after every four years for TIMSS and every five years for PIRLS. TIMSS considers the process and effect of opportunity to learn and therefore seeks to establish the linkages between the intended curriculum, the implemented curriculum and the achieved curriculum (Hooper et al., 2013; Neuschmidt, 2019). The intended curriculum is what the policy makers at the national level expect learners to be taught in schools. The implemented curriculum is what happens at the classroom level, that is, what the teachers teach learners in schools, and the achieved curriculum, i.e. what the learners learn and take home from schools (Hooper et al., 2013). To investigate the nexus between these curriculums, TIMSS collects learners' achievement data in mathematics and science and background information from parents, learners, teachers, school principals, and policy makers about teaching and learning contexts (Reddy & Hannan, 2018).

According to Martin et al. (2016), the TIMSS assessment contained nearly 800 assessment items, about 200 per grade for each curriculum area. These assessment items are spread over a number of test booklets. In 2015, TIMSS introduced a home questionnaire for the first time to be completed by the fourth grade (Grade 5 for South Africa), parents or caregivers in addition to the questionnaires routinely given to learners, teachers and school principals at each grade. TIMSS has the goal of helping countries make informed decisions about how to improve teaching and learning in mathematics and science. TIMSS can help countries to evaluate achievement goals and standards and to monitor learners' achievement trends in an international context. TIMSS provides an opportunity for South Africa to monitor the achievement trends of its learners over time and consequently the health of the education system. TIMSS results can be used to track academic progress through learner achievement (Isdale et al., 2017; Mullis & Martin, 2013).

2.3 TIMSS in South Africa

TIMSS was first conducted in 1995 and subsequently after every four years. TIMSS enables educational systems in different countries worldwide to compare learners' educational achievements and learn from each other's experiences in designing effective educational policies and curriculums. TIMSS helps show the variables that may be related to achievement both within a country and between different education systems (Mullis & Martin, 2013).

In South Africa, the Human Sciences Research Council (HSRC) conducts the TIMSS assessment. South Africa started at a very low level, with learners performing poorly but has since been improving over the years (Isdale et al., 2017; Reddy & Hannan, 2018). South

Africa participated in TIMSS for the first time in 1995, followed by other participations in 1999, 2002, 2011, 2015 and 2019 (Reddy et al., 2015). In 1995 and 1999, only the Grade 8 learners participated, and in 2002, learners in Grade 8 and Grade 9 participated in the TIMSS study. However, the Grade 8 learners performed poorly in every cycle of the assessments, resulting in South Africa choosing to administer the TIMSS assessments in 2011 to Grade 9 learners. The decision to let the Grade 9 learners write was made so that the learners' content knowledge presented in TIMSS could best match the curriculum coverage in South Africa. For this reason, and because of the poor performance at Grade 8 in previous cycles, South Africa only tested the Grade 9 learners in the 2011 cycle. For the TIMSS Numeracy 2015 study, Grade 5 and Grade 9 learners took part. South Africa is still to achieve a national average above 400 points, which signifies the low achievement or minimum mathematics competency (Isdale et al., 2017). TIMSS uses plausible values to approximate what each learner's mark would have been if they had answered to all items in the items pool. Learners only answered a fraction of the total items in the assessment[3]. Learners obtaining below 400 are considered to be lacking the basic knowledge of mathematics. Table 2.1 below gives the achievement scales used in TIMSS and their descriptors

Table 2.1

TIMSS International Performance Benchmarks

Achievement score	Implication of mark	Mathematical knowledge
Less than 350	Not achieved. Very low	Learners showed a lack of the most elementary mathematics knowledge
350-400	Not achieved but have potential to achieve	Although lacking the basic understanding of mathematics, these learners may be assisted to improve
400-475	Low	Learners may demonstrate some basic understanding in easy situations
475-550	Intermediate	Learners are able to demonstrate some basic understanding of mathematics
550-625	High	Learners are able to apply their knowledge and understanding in complex situations and to explain their reasoning
Above 625	Advanced	Learners can apply their knowledge and understanding to solve problems not seen before

Adapted from: Mullis et al. (2016).

[3] A detailed description of plausible values is presented in section 4.15 of chapter 4.

According to Reddy and Hannan (2018), South Africa obtained a national average of 276 in 1995 and 275 in 1999. In 2002, the national average was 2002 for Grade 8 learners and 289 for grade 9 learners. In 2011, the South African national average was 352. The results from 1995 until 2011 showed that South African learners were barely demonstrating the most basic competence in mathematics on average. In TIMSS 2015, South Africa obtained a national average of 372 for the Grade 9 learners. Reddy and Hannan (2018) point to the fact that though South Africa has been showing improvement judging by the national average, it is worthwhile to note that the country started from a very low base and also the fact that South Africa was one of the only three countries who tested learners at Grade 9 instead of Grade 8 in the TIMSS 2015 cycle.

2.4 TIMSS Numeracy 2015 Assessment

Countries that had learners who anticipated finding the TIMSS assessments too challenging at Grade 4 could choose to participate in the TIMSS Numeracy assessment pioneered in 2015, an easier version of the Grade 4 TIMSS mathematics assessment (Martin et al., 2016). The objective of the TIMSS Numeracy assessment is to assess fundamental mathematical knowledge, procedures and problem solving (Mullis & Martin, 2013). The questions used in the TIMSS Numeracy assessment were the same as those in the TIMSS mathematics assessment, except that they used easier numbers and procedures, which were more straightforward. About a third of the questions in the TMSS Numeracy assessment were the same as those in the TIMSS mathematics assessment. As a result, the TIMSS Numeracy assessment results could be compared and reported at the same achievement scale as the TIMSS mathematics results. The TIMSS Numeracy assessment was borne out of the realisation of the vast importance of literacy and numeracy skills in learners. It is mainly designed for those countries where learners' numeracy and literacy skills are not yet well developed (Mullis & Martin, 2013). South Africa participated for the first time at the Grade 5 level in TIMSS Numeracy 2015. Therefore, this is a baseline study that will form the basis for comparison with other similar studies in the future. This study aimed to provide the first South African nationally representative mathematics and science data on Grade 5 learners, which was internationally comparative and to establish learners' achievement in mathematics and science at an earlier level. This study would allow whatever policy interventions were required to improve the situation to be done much earlier (Isdale et al., 2017).

Fifty countries and seven benchmarking participants participated in the Grade 4 TIMSS Mathematics Assessment. Of these, seven countries, namely Bahrain, Indonesia, Iran, Kuwait, Jordan, Morocco and South Africa and one benchmarking participant, Buenos Aires, participated in the TIMSS Numeracy assessment. South Africa participated only in the numeracy assessment. It is important to note that in South Africa, Grade 5 learners were tested instead of Grade 4 learners. South Africa chose to participate in the TIMSS Numeracy assessment because of the low achievement of its learners in the previous TIMSS assessments at the Grade 9 level.

As part of TIMSS 2015, the Grade 5 data set enables a focus on the myriad of factors that are associated with mathematics achievement, including family characteristics, school contexts and comparison across educators (Isdale et al., 2017). The study specifically looked at the background factors associated with learner achievement, such as family backgrounds, household resources, individual learner characteristics and school contextual factors

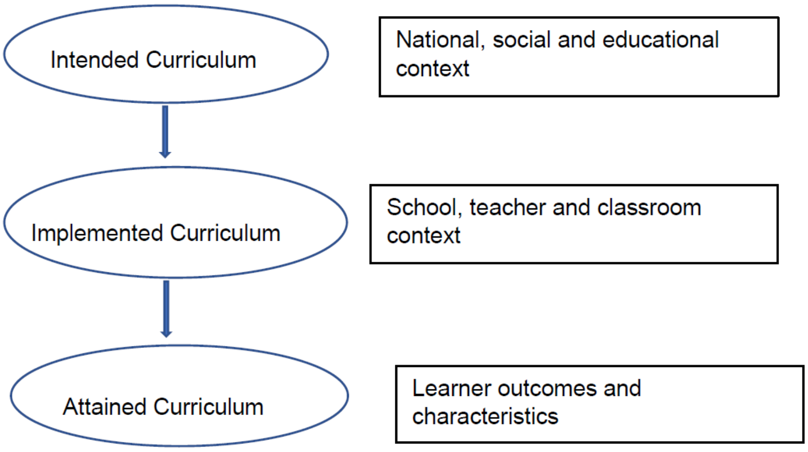
2.5 TIMSS Numeracy 2015: Design and Methodology

2.5.1 TIMSS Conceptual framework

According to Mullis and Martins (2013), TIMSS uses the three curriculums existing at the school as the conceptual framework used to organise concepts. These curriculums are the intended curriculum, the implemented curriculum and the attained curriculum.

Figure 2.1

TIMSS Conceptual Framework



Adapted from Mullis and Martin (2013).

- The intended curriculum represents the mathematics that the learners are expected to learn at a system level, that is, through policymakers as laid out in the countries' curriculum policies and statements. The expected knowledge, skills, values and attitudes to be acquired by learners are communicated in the intended curriculum (Mullis & Martin, 2013). The intended curriculum also includes how the system will monitor and evaluate the implementation of the curriculum in schools.

- The implemented curriculum is the mathematics that is taught to the learners by the teachers in the classroom. The implemented curriculum depends on what transpires in the classroom in terms of teaching and the interaction between the teacher and the learners. The implemented curriculum depends on the individual teacher's characteristics and interpretation of the intended curriculum.
- The attained curriculum is what the learners actually learn and take home (Mullis & Martin, 2013). The attained curriculum is how the learner understands their teacher and what the learner thinks about what they have learnt. The attained curriculum matters when the learner finally sits for an examination (Mullis & Martin, 2013).

2.5.2 Contexts for learning mathematics

According to the assessment frameworks for TIMSS 2015, the learning of mathematics and science is crucial in today's technologically centred society (Mullis & Martin, 2013). If a learner has a strong foundation in mathematics and science, they are likely to get a good career that will help them play a part in the prosperity and welfare of the global community (Reddy et al., 2015).

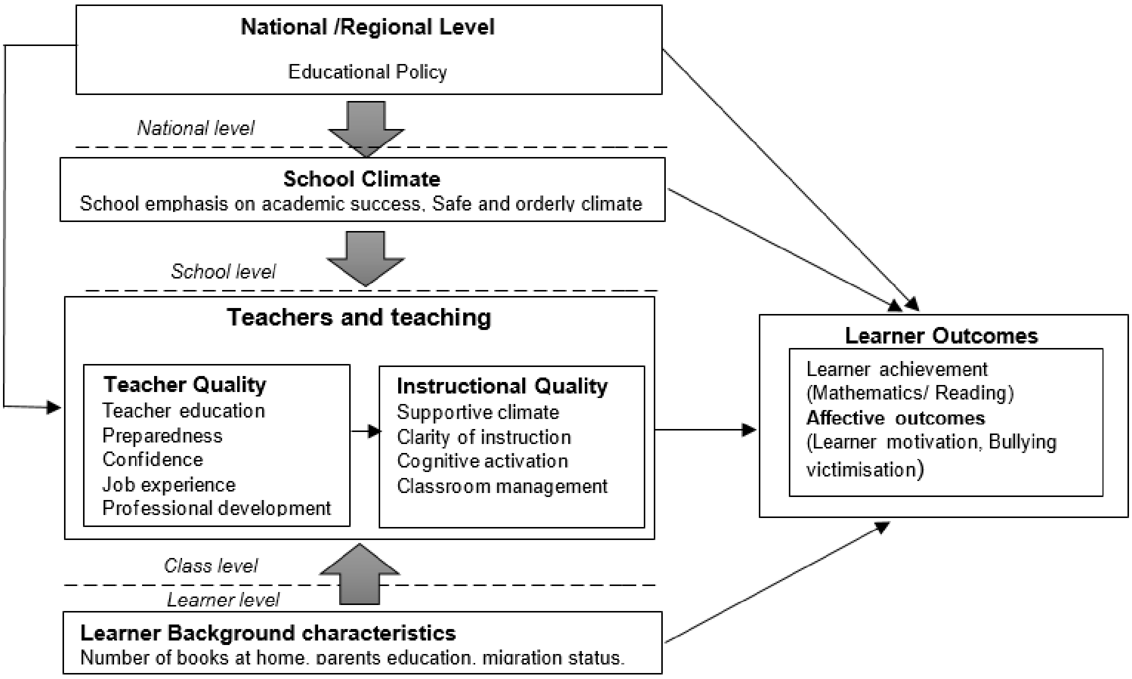
The TIMSS Numeracy 2015 study looked at different contexts which play a role in a child's learning. The five broad contexts explored were:

- "National and community contexts;
- School contexts;
- Classroom contexts;
- Home contexts; and
- Student and altitudes towards learning".

The contexts or background questionnaires provided some essential information about the learning of mathematics and science as affected by the different contexts. The following diagram depicts the relationship between the different learning contexts.

Figure 2.2

Relationship between different learning contexts



Adopted from Nilsen et al. (2016)

2.5.2.1 National and community contexts

According to the TIMSS 2015 assessment frameworks, cultural, social, political and economic factors contribute to how well learners will learn. Decisions made at the national level help in providing vital and effective mathematics and science teaching and learning. Some of these critical decisions will lie in areas such as economic resources, population demographics and geographical characteristics. How a country manages its wealth and economy will help determine how healthy the education system becomes. Democratic South Africa in 1994 inherited an education system that was deeply segregated on racial grounds. There were huge disparities in the funding of schools, with the apartheid government spending more money on educating a white child than they did on the majority blacks. After 1994, the South African government put all education systems in the country under a broad national education system and increased funding to schools serving the poor (Reddy et al., 2015). As a result of increased funding for education, more schools were built to increase access and close the enrolment gap between the rich and the poor (Department of Education, 2006). Primary education is compulsory in South Africa, and the enrolment rate is 100% (Howie et al., 2017). Most of the learners in South Africa (90%), attend government schools, of which 70% are in non-fee-paying schools (Howie et al., 2017; Spaull & Kotze, 2015; Van Der Berg et al., 2011). The total government budget on education in South Africa was 19% of the total government expenditure and 6% of the gross domestic product (GDP), which is much higher than other countries in Sub-Saharan Africa (Howie et al., 2017; Mlachila & Moeletsi, 2019; Spaull, 2013). The South African government also introduced free education to learners from poor backgrounds who go to Quintile 1, 2 or 3 schools (Isdale et al., 2017). The quintile system was introduced by the government to classify government schools nationally from most poor (Quintile 1) to the most affluent (Quintile 5). The availability of resources and equitable distribution of these resources to all learners may help improve learners' academic achievement.

The other important area covered at the national level is developing the curriculum to be followed. Through the Department of Basic Education, the South African government is responsible for formulating policies and the curriculum and setting up guidelines for implementation. The actual implementation and monitoring of policies and curriculum are left to the provincial departments of education. The curriculum followed in South Africa in 2015 was called the Curriculum and Assessment Policy Statement (CAPS). However, there has been a series of curriculum changes in South Africa since 1994, which has brought chiefly fatigue and confusion to teachers (Howie et al., 2017). A curriculum helps in defining the knowledge, skills and attitudes that learners will be expected to acquire after going through their schooling'; hence it is essential to have a curriculum that is not changed regularly to ensure stability in the education system (Howie et al., 2017). Another important policy dealt with at the national level is setting out the language of learning and teaching (LoLT). In South Africa, learners in the foundation phase, from Grade R to Grade 3, learn in their home language and then either English or Afrikaans is used from Grade 4 onwards (Isdale et al., 2017; Reddy &Hannan, 2018).

The South African government has also initiated some interventions to improve the teaching and learning of mathematics, with priority being given to improving the mastery level of learners (Reddy et al., 2015). Examples of such interventions are the National Strategy for Mathematics, Science and Technology and the Dinaledi Schools Project. The overarching goal of the interventions was to improve the delivery of quality mathematics knowledge to learners, especially the previously disadvantaged groups to improve their achievement. (Reddy et al., 2015).

2.5.2.2 Home contexts

Parents are the first teachers that any child will encounter, and they play a central role in the child's upbringing and success at school (Mohr-Schroeder et al., 2017). Information concerning home resources for learning, the language spoken at home, parental educational expectations, academic socialisation, early literacy and numeracy and availability of home resources are a measure of the SES of a family.

Research has shown that there is a relationship between SES and academic achievement (Friedman et al., 2016; Howie et al., 2017; Spaull, 2013; van der Berg, 2008, amongst others). Other factors related to SES are the parental level of education and parental career (van der Berg, 2008). Parents may therefore help the child's learning by working hard to provide the necessary resources. South Africa is rated as one of the countries in the world with the most inequalities (Graven, 2014; Spaull & Kotze, 2015). As a nation, South Africa is still reeling under the effects of the apartheid system, which marginalised the majority of the population from economic activity and left them impoverished (Graven, 2014). Most children in South Africa come from poor backgrounds where their parents or guardians are not gainfully employed. Seventy per cent (70%) of learners in South Africa come from poor backgrounds and are found in Quintile 1-3 schools, which are non-fee-paying schools, meaning that the parents are not expected to pay school fees (Graven, 2014; Spaull & Kotze, 2015). Learners from poor backgrounds lack resources like books, computers, and the internet at home to help them with their studies. Most poor parents in South Africa are likely to lack the time and zeal to be involved in home activities that may help in acquiring numeracy skills since they most likely work long hours (Graven, 2014). Learners from poor backgrounds are also more likely to be staying with guardians who are not their biological parents or to be coming from child-headed families (Howie et al., 2017).

According to Reddy et al. (2015), South African parents from poor households are much less likely to be involved in their children's work, especially in mathematics homework, since the parents may most likely lack the knowledge and skills needed in mathematics to their own poor mathematics background. However, according to Friedman et al. (2016), families with greater resources are more likely to be better educated and hence may be more involved with supporting their children's education, which may help increase the capabilities of their children.

Parents play a vital role in their children's learning by conveying how they expect their children to progress with their education. According to Isdale et al. (2017), most South African parents of the learners who participated in TIMSS Numeracy 2015 had high expectations about their children's education. The high expectations exhibited by South African parents are corroborated by findings from PIRLS 2016, where it was reported that parents showed exceptionally high levels of aspirations for their children's education (Howie et al., 2017).

2.5.2.3 School contexts

According to the TIMSS 2015 assessment framework, the school environment may affect learners' achievement and their chances of attaining their academic goals. Many factors within the school environment might affect how well a learner will learn. These include:

- The area where the school is situated;
- Effects of shortage of resources needed for effective mathematics teaching;
- Availability and quality of the teachers;
- Leadership qualities of the principal;
- The seriousness with which the school takes academic achievement; and
- School safety and discipline.

The school type (independent or public) and its location (urban, township or rural) are associated with the resources available to the school. For example, in South Africa, public schools in Quintile 4 and 5 are most likely to have more resources like good infrastructure, electricity, water supply, ablution facilities, libraries, and internet connectivity compared to public schools in Quintiles 1 to 3 and private schools serving the poor (van der Berg et al., 2011). According to Spaull (2013), South Africa has a two-tier education system, one serving the affluent few and the other serving the poor majority.

The SES of the school is a determinant of the quality of education likely to be offered by a school in South Africa. According to van der Berg et al. (2011), schools in rural areas might be located where some children will need to walk long distances to get to the school. The fatigue caused by learners walking long distances will most likely affect their concentration levels in school since they will already be exhausted. Schools located in towns in South Africa are generally better staffed than schools in rural areas or townships since many teachers want to work in town (van der Berg, 2008). The teacher-learner ratio is also likely to be small at wealthy schools compared to poor schools (Spaull, 2013). Teachers' preference to work in better-resourced urban schools leaves schools in rural areas and townships understaffed or manned by poorly qualified teachers. The shortage of quality teachers in poor schools may likely affect the quality of children’s education (Friedman et al., 2016; Graven, 2014; Reddy et al., 2015; Spaull & Kotze, 2015, van der Berg, 2008).

The socio-economic status of the collective learners going to a particular school may influence an individual learners’ achievement (Isdale et al., 2017; Reddy et al., 2015; Van der Berg et al., 2011) since those learners with a more affluent SES are more likely to be taught by well qualified teachers than learners of a low SES. High SES learners have greater social capital, which may help them reach their best potential, unlike low SES learners who might not have people from their areas who have excelled in education (Tan, 2017).

South Africa is one of the few countries participating in TIMSS where most of the learners speak a home language that is different from the language in which the test is conducted (Isdale et al., 2017). Only 31% of South African learners who wrote the TIMSS test in 2015 spoke the LoLT at home, placing them at a huge advantage over most other learners. The former disadvantaged groups going to poorly resourced schools are most likely to learn in a language different from the language they speak at home (Isdale et al., 2017; Mlachila & Moeletsi, 2019; Reddy et al., 2015). English and Afrikaans are the two LoLTs in South Africa from Grade 4 onwards, with English being the predominantly used language (Isdale et al., 2017).

2.5.2.4 Classroom contexts

Most of the learning and teaching transpire in a classroom, and the teacher is a key figure in the classroom. According to Spaull (2013), no education system can perform beyond the capacity of its teachers. The factors that affect learning inside a classroom involve the teacher's content knowledge and pedagogical skills (van der Berg et al., 2011).

A teacher knowledgeable in mathematics is more likely to enjoy the teaching and attend to their lessons more. Teachers with less content knowledge may be absent if it is time to teach concepts that they do not understand. The number of hours per week allocated to mathematics also determines how much content will be covered. Compared to other nations in sub-Saharan Africa, South Africa has a high percentage of primary school teachers who lack the required content knowledge to teach mathematics (Spaull, 2013). As a likely consequence of such a lack of content knowledge, an extensive review of learner workbooks of South African Grade 5 learners showed that curriculum coverage does not extend to the more challenging sections of the curriculum requiring high cognitive skills (van der Berg, 2011). According to Spaull (2013), teacher experience and preparation are important in that they will determine how well a teacher will deliver the curriculum. Teachers also need professional development to acquire new skills and keep up with the times, especially on using technology in learning. Teacher’s time management is a factor that is also crucial in that it ensures that teachers spend most of the instructional time teaching on the required content. According to van der Berg et al. (2011), South African teachers have a high absenteeism rate compared to other African countries that participated in SACMEQ II.

Teacher absenteeism in South Africa is a problem mainly in non-fee-paying public schools and much less of a problem in independent and public fee-paying schools (Isdale et al., 2017; Mlachila & Moeletsi, 2019). High rates of teacher absenteeism result in reduced learning time for learners, resulting in them not acquiring all the knowledge expected (van der Berg et al., 2011). According to Howie et al. (2017), about two-thirds of South African Grade 5 teachers surveyed for PIRLS 2016 were satisfied with their jobs, although there was no correlation between teachers' job satisfaction and learner achievement. Teachers are enforcers of good discipline in their classes and may also motivate the learners since they are the people who spend most of the time with the learners. (Friedman et al., 2016; Mullis & Martin, 2013).

South African classrooms are characterised by overcrowding, especially in schools serving the previously disadvantaged groups (Isdale et al., 2017; Spaull & Kotze, 2015). The huge class sizes make it difficult for the teacher to interact with every learner in the class, thereby making lesson delivery difficult (Spaull, 2013). According to van der Berg et al. (2011), classroom contexts and practices in South African primary schools are characterised by low time-on-task, poor curriculum coverage, low teacher morale and expectations and a shortage of resources like textbooks.

2.5.2.5 Learner characteristics and attitudes towards learning

In as much as all the other people are important for the academic achievement of a learner, it is the learner themselves who will ultimately determine how much they are prepared and able to learn. The attitude of the learner towards school and how it is related to academic achievement is one of the most studied areas in education. According to Reddy et al. (2015), South African learners who participated in TIMSS 2011 showed positive attitudes towards mathematics, which shaped their motivation (both intrinsic and extrinsic) to work hard in mathematics. South African learners also demonstrated great interest in doing mathematics and valuing mathematics (Isdale et al., 2017). According to the TIMSS 2015 assessment frameworks, helping learners to develop positive attitudes towards mathematics should be a key underpinning of the curriculum. Some factors at the learner level that may help determine how the learner will learn include the readiness of the learner to learn, learner motivation, learner self-concept, and learner characteristics (Mullis and Martin, 2013).

According to Juan et al. (2017), for a learner to learn effectively, they should come to school in a physiological and psychological state which permits learning. Lack of food and sleep deprivation have been cited as factors that hamper the ability of learners from low SES families to cope with learning (Friedman et al., 2016). One characteristic that sets South Africa apart from other middle-income countries participating in TIMSS is that it is riddled with massive inequalities and a massive proportion of people living in poverty (van der Berg, 2011). Learners going to Quintile 1-3 schools are more likely to come to school in a physiological and psychological state not conducive for learning because of their background of poverty. Other family factors which may also affect achievement are the educational background of parents, the language spoken at home, the levels of family support, race and ethnicity. Also, prior knowledge that the learner possesses is crucial in determining how many new things they will understand since any new thing a person learns is founded in what they already know (Friedman et al., 2016; Juan et al., 2017).

Learners' motivation is of paramount importance towards learning because a motivated learner can put in some extra effort to achieve more (Mullis & Martin, 2013). A learner should have both intrinsic and extrinsic motivation to succeed. Intrinsic motivation comes from within the learner, whilst extrinsic motivation comes from external sources such as teachers, parents and peers (Mullis & Martin, 2013). Gender has been considered a factor in mathematics achievement, with most communities having the innate belief that boys will generally do better than girls. However, in South Africa, boys' performance in mathematics has not been statistically different from the girls' performance (Reddy et al., 2015).

2.6 TIMSS Numeracy Assessment Framework

Friedman et al. (2016) state that "an assessment framework is intended to guide test development and help interested stakeholders understand the content and scope of the assessment". An assessment framework should include the following:

- A description of constructs being measured;
- Discussion of knowledge and skills that are being assessed;
- Specifications of the subject matter to be tested in the task;
- Description of the format of the task;
- Agreement on how the items are to be scored; and
- A summary of how the results of the assessment are to be communicated.

Since TIMSS is focused on monitoring different educational systems in various countries and reporting on trends over time, it is of paramount importance to have an assessment framework because it guarantees consistency in test development from one assessment cycle to the other (Friedman et al., 2016; Mullis & Martin, 2013). The TIMSS assessment frameworks for 2015 were updated from the TIMSS 2011 assessment frameworks to ensure continuity. The updating is significant as it allows the introduction of fresh ideas through contributions from the participating countries, enabling TIMSS to evolve and adapt to new curricula, standards, framework, etc., and remain relevant with changing times. It is the duty of the national research coordinators (NRCs) from the participating countries to consider any new inputs and ensure that the new updates to the assessment framework are responsive to each country's concerns (Mullis & Martin, 2013).

2.6.1 Importance of learning mathematics

According to the TIMSS 2015 assessment framework, the learning of mathematics is fundamental and essential in that it helps one become a knowledgeable and functioning individual. The learning of mathematics helps one contribute to society in terms of solving the many problems that people face. If a person understands mathematics, they are more equipped to lead a productive personal life that embodies good health habits, makes informed financial decisions and is effective in problem-solving. Countries with people good in mathematics will reap the rewards of improved medical, housing and transportation conditions. Mathematically literate people are more likely to be concerned with environmental protection and sustainable resources (Mullis and Martin, 2013).

2.6.2 TIMSS Numeracy–Mathematics content and cognitive domains

The assessment framework for TIMSS Numeracy 2015 was organised around the context and cognitive dimension. The context dimension spells out the subject content to be tested whilst the cognitive dimension points to the thinking processes to be tested (Mullis & Martin, 2013).

2.6.3 Content Domain for TIMSS Numeracy 2015

TIMSS tested three content domains at Grade 4 or Grade 5: numbers, "geometric shapes and measures, and data display. Each domain specifies the subject matter spells to be assessed and requires learners to demonstrate a certain range of knowledge and skills" knowledge range and skills that learners should possess. Each content strand comprises topic areas, and each area is broken down into smaller sub-topics as illustrated by Table 2.2.

Table 2.2

TIMSS Numeracy 2015 content domains and their percentage contribution

Content domains	Percentage Contribution
Whole Numbers	(50%)
Fractions and decimals	(15%)
Shapes and Measure	(35%)

Number domain: This domain was made up of three topic areas: Whole numbers; fractions and decimals; and expressions, simple equations and relationships. Of the 50% contribution of the number content domain, 25% comprises whole numbers, fractions and decimals contribute 15%, and 10% is made up of expressions, simple equations and relationships. The number domain is important because all other content domains rely on a learner's understanding of numbers. Understanding whole numbers is critical in early primary school grades as it lays the foundations for them to do simple addition, subtraction, multiplication and division problems. *Fractions and decimals* are important topics as they form the basis for calculations involving numbers that are not whole numbers (Mullis & Martin, 2013)

Geometric shapes and measure domain: This content domain comprised two topic areas: Points, lines and angles, and two- and three-dimensional shapes. Learners were expected to understand the characteristics of lines and the angles between lines. They also required an understanding of different geometrical shapes, especially 2- and 3-dimensional shapes. Learners must also be able to identify and draw different shapes and solve problems involving the relationships between these shapes. Learners were expected to calculate areas, perimeters and volumes of the different geometrical shapes (Mullis & Martin, 2013).

Data display domain: Only one topic, Reading, interpreting and representing, was under this content domain. In this topic, learners were expected to represent data in the form of diagrams, tables, graphs (bar-graphs, histograms, line graphs and pie-charts). This visualisation of data helps make data visible, making it clear and concise (Mullis & Martin, 2013).

2.6.4 Cognitive domains for TIMSS Numeracy 2015

Cognitive domains relate to the thinking abilities of learners. This thinking ability can relate to how they process information in their minds to remember what they have been taught or to linking new situations with what they already know. It also entails using the knowledge acquired in class to solve problems that might be familiar or new. TIMSS assesses three cognitive domains: Knowing, applying, and reasoning (Mullis & Martin, 2013).

The *knowing cognitive domain* is about recalling or remembering what one has been taught. Knowing is about facts, concepts and procedures. The knowing domain is the cornerstone in the learning of mathematics as it lays a solid foundation of understanding mathematics. Problem-solving and other mathematical applications hinge on how much a learner can recall and the concepts they understand. It is through recalling facts that a learner learns the basic language of mathematics and mathematical concepts. Routine mathematics procedures help connect knowledge of mathematics concepts to their applications in real life (Mullis & Martin, 2013).

The *applying cognitive domain* is about how mathematics may be applied to different settings. This cognitive domain relies on all that has been gained in the *knowing cognitive domain: understanding and recalling facts, concepts,* and procedures to solve familiar problems. The applying *cognitive domain* leads to problem-solving with an emphasis on familiar and routine tasks. The problems may be of a real-life or purely mathematical nature (Mullis & Martin, 2013).

The reasoning domain involves questions that check the ability of learners to be problem solvers even in new contexts different from what they have been taught. In this cognitive domain, problem-solving is the fundamental tenet. Problems may be novel or unfamiliar, but learners should be able to think logically and systematically to find solutions. The reasoning cognitive domain involves higher-order thinking since it involves connecting the known to the unknown situations. Learners must use the knowledge and skills they have acquired to tackle or solve unfamiliar problems (Mullis & Martin, 2013).

Table 2.3

TIMSS Numeracy 2015 cognitive domains and their percentage contribution

Cognitive domains	Percentage Contribution
Knowing	50%
Applying	35%
Reasoning	15%

2.7 Instruments Used in TIMSS Numeracy 2015

The IEA devised different instruments regarding learner achievement and background information. The IEA used a collaborative approach in designing the new instruments to be used for each TIMSS cycle. Most of the countries that participated in the TIMSS 2015 study were involved in developing the instruments. These instruments included achievement tests, home questionnaires completed by parents, learner questionnaires completed by learners, teacher questionnaires completed by the teachers teaching mathematics in Grade 5, a school questionnaire completed by the school principal, and the curriculum questionnaire completed by the National Research Coordinator. The TIMSS Numeracy 2015 assessment of learners and the home questionnaires completed by parents or caregivers were used to answer the research questions of the present study (Mullis & Martin, 2013).

2.7.1 Achievement test

TIMSS has reliable measurement, comprehensive description and understanding of mathematics knowledge one of its main goals. The achievement test is the assessment that was written by the learners (Mullis et al., 2016). TIMSS Numeracy had new items (or questions) since it was the first time it was administered. One hundred fifty-one new items were developed and field-tested for TIMSS Numeracy 2015.

The national research coordinators (NRC), with the help of experts from the participating countries, had the task of coming up with new items and scoring guides for constructed response items. The NRCs reviewed the new items before taking them for field tests to assist with choosing items for the assessment after the field test. These new items were then subjected to some rigorous validation process to make sure that they meet the TIMSS standards. At every stage of the development process, additional expertise was sought from external mathematics specialists who worked with the TIMSS staff. More advice and support were also provided by the Science and Mathematics Item Review Committee (SMIRC), which was a body of experts in mathematics and science nominated by the participating countries. SMIRC was made up of six mathematics and ten science experts who had an oversight role in reviewing proposed mathematics and science frameworks, reviewing draft field test guidelines and scoring guides, and reviewing proposed item blocks in conjunction with field test results.

According to Ebbs and Korsnakova (2016), the TIMSS assessment items were developed in English and then translated into 43 different languages used in the different participating countries. Each participating country was then mandated to find linguistic experts to go through the translated material and ensure it was in line with the original English version. The translations and verification process are done meticulously to ensure high-quality translations that are internationally comparable and appropriate for each country’s context and education system. Even for those countries like South Africa who use English as one of the testing languages, adaptations had to be made to the materials to accommodate different English variations used in each country (Ebbs & Korsnakova, 2016). In South Africa, assessment items were also translated into the Afrikaans language (Isdale et al., 2017). For schools to acquaint themselves with the TIMSS instruments, past items used in previous studies were released to the public and also sent to the participating schools so that they could prepare for the next rounds of assessment (Mullis et al., 2016)

2.7.2 TIMSS Numeracy 2015 assessment booklet design

According to Mullis and Martin (2013), it is not feasible for a learner to answer all the items in the pool of items because TIMSS has more items in the assessment than could be answered by a learner in the allocated time. To ensure that learners write a test they can reasonably finish, TIMSS uses a matrix sampling approach where items are grouped into blocks (Nilsen et al., 2016). The TIMSS Numeracy 2015 items were spread across five booklets, with each booklet having two blocks. Each learner was expected to answer questions from one booklet only. The TIMSS Numeracy assessment booklets were made up of ten blocks of numeracy items labelled No 1 to No 10. Each item appeared in two booklets to create a linkage between the booklets. Booklets were distributed in the participating classrooms in a way that ensured that there was uniformity in terms of the ability of the groups of learners to answer different booklets. Since TIMSS Numeracy 2015 was the inaugural cycle for the TIMSS Numeracy assessment, all the items were new. The TIMSS Numeracy 2015 item blocks made use of multiple-choice and constructed-response items. Learners taking TIMSS Numeracy assessments were anticipated to require about 18 minutes to complete each item block, implying that a total of three hours would be needed for the ten blocks. The ten numeracy blocks were spread across five learner achievement booklets, with each booklet composed of four blocks of numeracy items (see table 2.5). Therefore, each learner was expected to answer all four blocks in one assessment booklet, thereby requiring 72 minutes (Martin et al., 2016).

Table 2.4

TIMSS Numeracy 2015 Item Blocks

Block	Description
NO1	New items for TIMSS Numeracy 2015
NO2	New items for TIMSS Numeracy 2015
NO3	New items for TIMSS Numeracy 2015
NO4	New items for TIMSS 2015 (Item block MO2)
NO5	New items for TIMSS Numeracy 2015
NO6	New items for TIMSS Numeracy 2015
NO7	New items for TIMSS Numeracy 2015
NO8	New items for TIMSS 2015 (Item block MO8)
NO9	New items for TIMSS Numeracy 2015
N10	New items for TIMSS Numeracy 2015

Table 2.5

TIMSS Numeracy 2015 learner achievement booklet design

Learner Achievement Booklet	Part 1		Part 2	
Booklet 1	No1	No2	No4	No3
Booklet 2	No3	No4	No6	No5
Booklet 3	No5	No6	No8	No7
Booklet 4	No7	No8	No10	No9
Booklet 5	No9	No10	No2	No1

Four of the ten numeracy blocks were then released to the public as limited release items, two of these were the shared TIMSS 2015 assessment blocks of items (Isdale et al., 2017).

2.7.3 Background questionnaires

The collection of contextual information is key to having a holistic picture of an assessment and how learners are likely to achieve (Friedman et al., 2016). Contexts help to bring out the relationships between learning outcomes and background factors and the relationship between contexts and learners' performance. These relationships will help with decision-making regarding the enactment of policies (Friedman et al., 2016; Mullis & Martin, 2013). TIMSS Numeracy 2015 included several background questionnaires to better understand the achievement of scores covering learners' lives in different contexts at different times, for example, home background and school environments. These different contexts give rise to some underlying factors which might affect the child's learning. How learners interact with their parents, whether parents partake in some home activities with their children, and the availability of resources are home-level factors possibly associated with learner achievement. Five different questionnaires were administered on top of the assessment instruments to contextualise the different factors that may affect learning.

1. ***Learner questionnaire***

Learners who participated in the TIMSS Numeracy 2015 assessment also completed a learner background questionnaire. The questionnaire had questions about each learner's individual characteristics such as age, gender, grade repetition etc. The questionnaire also covered the home environment in terms of measures such as SES (e.g. family possessions, resources at home, parents' education and occupation), the language spoken at home, home activities done and parental support. Finally, the questionnaire also asked about the learning environment at school (e.g. the relationship with the teacher, activities given during instruction, feedback given by the teacher), learning experiences at school and how the learner viewed mathematics as a subject. (Isdale et al., 2017).

2. ***Teacher questionnaire***

The teacher questionnaire was completed by the mathematics teachers of the learners who participated in the TIMSS Numeracy 2015 study. The questionnaire collected information on teacher characteristics and the classroom environment where the teaching and learning of mathematics occurs. The classroom and teacher-related activities are viewed as contributing the most to the success of a learner. Therefore, it was important to collect information from the teacher about what happens in the classroom. Teachers were asked about things like resources in their classes, for example, computers, whether they enjoyed teaching mathematics, how often they gave homework and how they assessed the learners.

They were also asked about the highest qualifications they have and their professional development plans. The questionnaires had to be completed within 30 minutes.

3. Home questionnaire

The home questionnaire was completed by the parents or caregivers of the learners who wrote the assessment test. It was intended to collect information about learners' home contexts and the learning experiences at home. The home questionnaires were designed to enable the gathering of information on variables that were thought to have a relationship with learner achievement. This questionnaire was particularly geared towards collecting information about a child's early learning experiences. The home questionnaire asked about the learner's home learning environment, covering aspects involving pre-school educational activities, learner school preparedness, school involvement, parents' ability to assist with homework and views about safety at school. The TIMSS 2015 cycle was the first one where a home questionnaire was administered at Grade 5 level. The parents were given 30 minutes to complete the questionnaire (Martin et al., 2016).

4. School questionnaire

The school questionnaire was given to the principal or head teacher in all the sampled schools. The school questionnaire had questions about how the school was managed in terms of the resources available, for example, computers and use of information technology, internet connectivity and staffing. It had questions on the teacher body, teacher attendance, and teacher development opportunities. The questionnaire also had questions on how the school was managed, background information about the principal, the school curriculum, the language of instruction, assessment and evaluation. The school questionnaire also had questions pertaining to how the school interacted with and involved parents in the school activities.

5. Curriculum questionnaire

The National Research Coordinator was responsible for completing the curriculum questionnaire. The curriculum questionnaire had questions on the education system for the country in terms of its structure, and the curriculum followed both in public and in independent schools (Isdale et al., 2017). The NRC answered questions about the mathematics curriculum, standards for instruction and other related policies, for example, early childhood development programmes and teacher training processes (Hooper et al., 2013). The questions in the curriculum questionnaire focused mainly on the organisation and content of the national curriculum. The subject content that the learners were supposed to have covered by Grade 5 were addressed in the curriculum questionnaire (Isdale et al., 2017).

To understand the educational systems of the different participating countries, TIMSS documents each country's educational policies and mathematics and science curriculums. The information is then put together into a TIMSS encyclopaedia that becomes an important resource and referral for those who would like to know more about the educational system of a particular country. Each participating country contributes a chapter that describes its educational system in terms of mathematics and science curricula, how the subject is taught in primary and secondary grades, the teacher qualifications, and how the assessments and examinations are conducted (Mullis & Martins, 2013)

2.7.4 Field Testing

Before conducting the actual TIMSS assessment, TIMSS conducts a field or pilot study to gauge the level of preparedness of the designed instruments. The field study helps to give a picture of what is likely going to happen during the main assessment. Doing a field study helps provide information about how well the designed items function and gives room for corrections and improvements. The field study also allows the validity and reliability of questionnaires to be ascertained (Mullis et al., 2016).

In preparation for the field test, a probabilistic sample is drawn at the same time as the sample of the main survey, using the same sampling procedures and sampling frame as the main study (Mullis et al., 2016). The sample size for the field study was 5% of the main sample. Fifteen schools with a target population of 600 learners were sampled. The sample design ensured that the schools sampled for the field study were automatically excluded from the main study. Only schools in Gauteng and KwaZulu-Natal provinces were chosen for the field study. The schools selected were to be located within 100 km from the city of Pretoria in Gauteng and the same for Durban in KwaZulu-Natal (Isdale et al., 2017; Mullis et al., 2016).

NRCs and experienced item writers from the participating countries and staff from the TIMSS and PIRLS International Study Centre developed new items for the field test. The team that included consultants and chief consultants in item design thoroughly reviewed these newly designed items. After being reviewed, these items were then put into blocks that were also reviewed by the TIMSS 2015 SMIRC and the NRCs before the production of the field instruments. All the suggested changes and revisions to the instruments were made at the TIMSS and PIRLS International Study Centre. The final version of the test booklets was given to the NRCs to start translating the field test material into the languages of learning and teaching used in their respective countries. The NRCs and their scoring supervisors were trained for the scoring of field test constructed response items (Mullis et al., 2016)

2.8 Participants for the TIMSS Numeracy 2015 Assessment

The main participants for TIMSS Numeracy 2015 were learners doing Grade 5 in that year in South Africa. These learners wrote the achievement test as well as completing a learner questionnaire. Parents, mathematics teachers and principals of the selected learners also completed questionnaires.

2.9 Sample Selection for TIMSS Numeracy 2015 in South Africa

Drawing a representative, unbiased and random sample provides a more accurate indication of measurement. All potential participants in the sampling frame should have an equal chance of being included in the sample if a representative, random sample is drawn. This section explains the sampling process for TIMSS Numeracy 2015 in terms of the exclusions used, the types of schools in South Africa, how the sampling plan was obtained and how the final sample was drawn.

2.9.1 National coverage and exclusions

TIMSS is designed to be drawn from a comprehensive sampling frame to describe and summarise achievement in mathematics and science. However, sometimes it is not possible to sample a country-wide representative group because of reasons which might be political, organisational or operational (LaRoche et al., 2016). For example, some schools may be located in extremely remote and inaccessible areas or might belong to a different education sub-system that offers a curriculum very different from the mainstream education system. Schools, which solely served learners with special needs, were left out of the TIMSS Numeracy 2015 study. Schools with very few learners in the target grade were also excluded from the sampling plan. For the South African sampling, schools were excluded if they had less than ten learners in the grade (LaRoche et al., 2016). At the learner level, learners with intellectual or functional disabilities were not included in the sampling frame. Learners deemed to have functional disabilities are those who, by the professional opinion of principals and/or teachers, cannot comprehend or follow what other learners do in class. However, learners could not be excluded from the study because of poor performance or behavioural problems (LaRoche et al. 2016).

2.9.2 Types of Schools

South Africa has two types of schools, namely government schools (public schools) and independent schools (Fiske & Ladd, 2004). Public schools are government-owned, and most of the teachers are employed by the Department of Basic Education (DBE). Independent schools are self or institutionally governed, and their teachers are employed by the independent school or their associated organisation. The public schools are categorised into five quintiles. The quintiles are a ranking of schools from the poorest to the wealthiest. Quintile 1 accounts for 20% of schools with the least resources, and Quintile 5 represents the wealthiest 20% of the public schools in South Africa (Fiske & Ladd, 2004; Spaull, 2013). Quintiles 1 to 3 receive more government funding and are non-fee-paying schools. Independent schools are a combination of high-fee private schools and low and non-fee-paying schools funded through private avenues.

2.9.3 Stratification of schools

According to Isdale et al. (2017), there was explicit and implicit stratification of schools during sampling for TIMSS Numeracy 2015. Under explicit stratification, schools were sampled according to the type of school (independent or public), by province in the case of public schools, relative to socioeconomic status (SES) within the independent schools, and by language of learning and teaching (Afrikaans and English). Implicit stratification involved grouping schools by the level of performance or achievement (lower quintiles, middle quintiles and higher quintiles) per province.

2.9.4 National sampling plan

The national research coordinator (NRC) submits school databases to the IEA, who use the sampling framework to draw sets of sampled schools and classrooms. The sampling frame is the first aspect to be determined, which is a list of all schools with learners enrolled in the grade of interest (LaRoche et al., 2016). In South Africa, the sampling frame was the list of registered schools supplied by the Department of Basic Education (DBE). This list contained 16 194 schools with a population of 924 392 learners in Grade 5 (LaRoche et al., 2016). The final sample was drawn from the sampling frame, and the number of learners enrolled in the grade of interest determines the probability of the school being selected. Statistics Canada selects the sample of schools and classes, providing two replacement lists for when schools decline to participate. The NRC, Statistics Canada, and staff from the IEA Data Processing and Research Center work together to select the national school samples and ensure that all supporting documents are available for the selected schools to be tracked easily (LaRoche et al., 2016).

2.9.5 South African sample design for TIMSS Numeracy 2015

According to Isdale et al. (2017), a two-stage stratified cluster sampling design was used. Statistics Canada drew up a nationally representative sample and stratified the sample by province and school type (public and independent). The stratification of schools provides a representation of a sample for generalisation to sections of the population, for example, an accurate estimation of numeracy achievement in independent schools. Stratification also built to a proportional representation of the sample into the framework (LaRoche et al., 2016).

In the first stage, 300 schools were selected from the 17 824 schools provided by the Department of Basic Education (DBE) (Isdale et al., 2017). The second stage involved the selection of an intact Grade 5 class within each sampled school. The sampling frame was made up of schools offering Grade 5, which would have been correctly allocated to a stratum (group). Before classes could be sampled, schools had to supply class information for all Grade 5 classes. An intact class was then randomly selected using Windows Within-School Sampling Software (WinW3S) provided by the IEA (LaRoche et al., 2016).

In general, one class per school was randomly selected because it is anticipated that every school chosen will participate in the study. However, getting all the chosen schools to participate might not always happen, and, in those rare cases when some schools fail to participate, there were replacement schools on a separate list. Choosing schools around the sampled school as a replacement ensures that the sample size will remain almost the same since schools were arranged by size in the sampling frame (LaRoche et al., 2016). Out of 300 schools that were selected in South Africa, 297 schools participated, with 10 932 learners, 10 493 parents/caregivers and 298 mathematics educators taking part in the study (Isdale et al., 2017). Table 2.6 shows how the schools were sampled in the different provinces to develop the South African national sample.

Table 2.6

Schools sampled for TIMSS Numeracy 2015

	Intended number of schools sampled	Attained number of schools where TIMSS 2015 was administered	First replacement school used	Second replacement	Total schools	Total learners
	38	37			37	
Eastern Cape						
Free State	29	29			29	
Gauteng	46	42	3		45	
KwaZulu-Natal	35	35			35	
Limpopo	34	34			34	
Mpumalanga	29	29			29	
Northern Cape	29	29			29	
North West	29	29			29	
Western Cape	31	29		1	30	
Grand total	**300**	**293**	**3**	**1**	**297**	**10932**

Source: Isdale et al. (2017)

2.10 Data Collection and Monitoring

TIMSS seeks to provide countries with reliable data which will include their learning contexts and indicate the level of achievement of the learners (Mullis et al., 2016). For the data to be reliable, it has to be collected in a standardised way. Some standard operations procedures were collaboratively developed between the TIMSS and PIRLS International Study Center, IEA DPC, IEA secretariat, Statistics Canada, and TIMSS NRCs to ensure uniformity in the collection of data across participating countries (Johansone, 2016). The operations procedures are continually updated with each cycle of TIMSS to make the data collection process more efficient and incorporate the latest technologies to automate routine activities (Johansone, 2016).

In the Southern Hemisphere, where South Africa lies, data collection for the main study took place in October-December 2014. Before the main study was conducted, the field test was conducted first in March-April 2014. This field study was conducted using the same standard operating procedures as the main study but on a much smaller scale. The field test acted as a “dress rehearsal” of what was expected to happen during the main study and check item functioning (Isdale et al., 2017). The field test enabled the NRCs and their teams to get used to the operational procedures, and the feedback from that experience enabled improvements to be made to the procedures. At the end of the field test process, the NRCs assessed the quality of the instruments and the effectiveness of the operations procedures and documentation (LaRoche & Foy, 2016). The field test also generated items statistics to ensure that psychometrically functioning items are included in the assessment. Items that had poor measurement properties, such as being too easy or too difficult, were sieved from the item pool (LaRoche & Foy, 2016).

Administration of the instruments and data collection was the sole responsibility of the NRC of each country (Johansone, 2016; Mullis & Martin, 2013). However, the IEA appointed an international quality control coordinator who randomly checked at least 10% of the sample during data collection for adherence to procedure. The NRC also appointed an internal quality control team. TIMSS Numeracy 2015 administered a series of tracking forms to record the sampling procedures, assign assessment instruments and collect information about the school, teacher and learners. The tracking forms were also used to solicit information about whether each respondent was going to participate in the study and the data collection and verification process (Johansone, 2016).

The NRC played a pivotal role during the data collection process. Internationally, the NRC was the point person for each participating country and had to keep track of all the ongoing activities and document them every step of the way. The NRCs had a manual on the procedures and guidelines to follow though they were allowed to customise them, where necessary, for their unique contexts (Johansone, 2016). The functions performed by NRCs are elaborated in the table below.

Table 2.7

Roles played by the NRCs

Task	Activities of NRC
Sampling of schools and classes	• Sampling schools • Sampling classes within the sampled schools
Preparing the instruments for assessment	• Translating, adapting, assembling and printing test materials • Checking test materials and storing them
Administering assessment	• Error detection during packaging shipment to schools • Identification and training of school coordinators
Implementing national Quality Control Program	• Sending National Quality Control Observers to some schools • Conducting quality assurance
Preparing for and scoring constructed response items	• Organising training for scorers for constructed response items
Creating databases	• Data entry and quality control • Hiring data entry staff. • Training in data management

Source: Johansone (2016).

The TIMSS Numeracy 2015 data included the collection of background questionnaires and achievement booklets. The achievement booklets were the main instrument for TIMSS Numeracy 2015, and necessary precautions were taken to ensure the validity of the results. Externally selected collectors had the task of administering the TIMSS Numeracy 2015 assessment at schools and documenting learner participation. The TIMSS NRC was responsible for supplying the standard guidelines and procedures to the school coordinators (Johansone, 2016). In South Africa, administering the TIMSS Numeracy 2015 assessment was outsourced to an external fieldwork company that had a lot of experience in the field of educational assessments (Isdale et al., 2017).

Each sampled learner received one of the ten booklets according to the systematic allocation plan enabled by the WinW3S sampling software. Each learner also received a learner questionnaire labelled so that it could be linked to the achievement booklet. Parents of the learners writing the test were allocated a parent questionnaire called *The Early Learning Survey*, which was also linked to the achievement booklet. A teacher questionnaire and a school questionnaire were given to the teacher of the learners and the school principal, respectively (Johansone, 2016).

2.11 Types of Items and Scoring Procedures–TIMSS Numeracy 2015

According to Isdale et al. (2017), there were 102 assessment items in TIMSS Numeracy 2015. Since this was the pioneering cycle for TIMSS Numeracy, all the items were new; there were no items carried over from previous cycles. The TIMSS assessments comprise multiple-choice items and constructed-response items (Mullis et al., 2016).

Multiple-choice items

Multiple choice questions accounted for about half the total number of points attainable by learners in the TIMSS assessment (Isdale et al., 2017). There were 46 multiple-choice items in the TIMSS Numeracy 2015 assessment. Each multiple-choice question had four response options with only one correct. Most multiple-choice questions were worth one score point, although some compound multiple choice questions could be worth two score points (Mullis & Martins, 2013). Multiple-choice questions are used to test any of the behaviours in the cognitive domains. The advantage of multiple-choice questions is that they allow for the timeous testing of a whole range of content in a valid, reliable and relatively cheap way (Isdale et al., 2017; Mullis & Martins, 2013).

The drawback with multiple-choice questions is that they do not allow learners to make further explanations to support their claim. Hence, multiple-choice questions may not be appropriate for assessing the ability of learners to make complex interpretations or evaluations (Mullis & Martin, 2013). The items in the multiple-choice questions were written in simple and clear language for them to be accessible to an average Grade 5 learner. The wrong options were phrased to look like possible answers, but not in a way to deceive or confuse learners (Mullis et al., 2016)

Constructed response items

This type of test item allows learners to accompany their worked-out answers with statements that show their reasoning. They could also use sketches and diagrams to elucidate their answers. Constructed response items are ideal for assessing the ability of learners to interpret and explain concepts based on prior knowledge and experience. Each question is normally worth one or two score points. Because constructed response items do not have a specific answer like in multiple-choice questions, scoring becomes extremely important to ensure fairness and consistency. A scoring guide helps in guiding scorers on which types of answers are acceptable and which ones are not acceptable. Scorers have to be trained so that they will score with minimum discrepancies to achieve this. The IEA availed samples of learner responses from the TIMSS 2011 cycle from each country, and these samples were then used in training scorers in 2015 (Mullis & Martin, 2013). Open-ended items needed reliability and validity scoring to guarantee the quality of assessments. Training in this regard was provided by the IEA, together with comprehensive scoring guides and procedures. The TIMSS and PIRLS International Study Centre conducted training sessions for the NRCs and their scoring supervisors to score the constructed-response items (Mullis et al., 2016). In South Africa, the HSRC employed teachers and tertiary level students to do the scoring. The HSRC staff then moderated these score sheets on an ongoing basis to check and ensure accuracy and consistency. Five per cent of the booklets were marked twice by different scorers (Isdale et al., 2017). Table 2.8 depicts an example of a multiple-choice item.

Table 2.8

Examples of achievement items

Multiple-choice item	Constructed response item
Joan had 12 apples. She ate some apples, and there were 9 left. Which number sentence describes what happened? Ⓐ 12 + 9 = □ Ⓑ 9 = 12 + □ ● 12 − □ = 9 Ⓓ 9 − □ = 12	Tom ate $\frac{1}{2}$ of a cake, and Jane ate $\frac{1}{4}$ of the cake. How eat altogether? Answer: $\frac{3}{4}$

Source: Isdale et al., (2017)

2.12 Quality Assurance and Monitoring During Test Administration

Strict quality control measures were in place before, during and after the administering of the test. Quality assurance was also done through some international quality controllers assigned by the IEA. The International Quality Control Monitors (IQCMs) implemented the international quality assurance programme and visited a sample of 15 participating schools during the testing session. The IQCMs would be physically present in assessment sessions noting the levels of adherence to the TIMSS standard procedures and any deviations thereof. The IQCMs did not report directly to the NRCs, and their role was independent of the NRCs (Johansone, 2016). The school administrators followed guidelines and procedures given to them by the NRC.

The TIMSS achievement tests were written in two sessions, with a 30 minutes break between the sessions. Each session was 36 minutes long, to make a total of 72 minutes for the test. In cases where at least 10% of the sampled learners were absent on the test day, the school administrators were expected to find a day for the learners to write the assessment (Johansone, 2016). At the end of the assessments at schools, the school administrator was expected to hand back all documentation and instruments to the NRC for scoring and data capturing.

After the learners had written the test, the booklets were scored. Particular care and consideration were given to the scoring of constructed response items to ensure consistency in marking.

2.13 Data Capture and Cleaning

Each national centre was responsible for capturing all data from achievement booklets and questionnaires into computer data files. The data was then captured using a software program supplied by the IEA called Data Management Expert (DME). The NRC verified all data captured against the original capture to minimise errors (Meyer et al., 2016). The national centres were advised to have 5% of each instrument entered by two different persons to check the reliability of the data entered. This double entry of instruments was done to ensure a common understanding of the data entry process and to keep variations at a minimum (Meyer et al., 2016).

Once the NRCs scrutinised the data, it was sent to the IEA DPC for final cleaning. The NRCs also sent the documentation related to the data capture process to the IEA DPC. The IEA DPC checked the data for inconsistencies, formatted it, and put it in a form that guaranteed a standard output (Meyer et al., 2016).

2.13 Reporting TIMSS Numeracy 2015 Achievement Scores

The learners who participated in the TIMSS Numeracy 2015 assessment responded to only a fraction of the items in the pool. To get an estimate of the mark each learner would have earned if they had answered all the items in the items pool, IRT scaling was used (Martin et al., 2016). The learner achievement scores were obtained from the learners' responses to the achievement test, which were then combined with the demographic background of similar learners to arrive at an estimated score for the learner (Isdale et al., 2017. Item

Response Theory (IRT) scaling was used to get plausible (possible) values which approximated the learners' achievement score (Martin et al., 2016). However, it is important to note that Plausible Values (PVs) are not designed to approximate the achievement score of a specific learner but are imputed scores for learners with similar response patterns who share similar background contexts. The plausible values had a mean of 500 and a standard deviation of 100. The PVs are useful since they allowed for comparing achievement between different iterations of TIMSS (Martin et al., 2016).

2.14 METHODOLOGICAL NORMS

2.14.1 Validity of TIMSS Instruments

Validity is the extent to which an instrument measures what it purports to measure. According to Mohajan (2017), the validity of a research instrument assesses the degree or extent to which the instruments measures that which it is designed to measure. Validity is, therefore, the degree to which the results of a study are an accurate indication of the latent trait. In this regard, the achievement items and the TIMSS questionnaires should accurately measure the intended constructs (Mohajan, 2017). Mullis and Martin (2008) also defined validity as the extent to which the deductions or conclusions made from the study can be backed by evidence. For the results of a study like TIMSS to be trustworthy, the study should have a high degree of both internal and external validity (Mohajan, 2017).

Internal validity is enhanced by ensuring sufficient control of the variables other than the variable under investigation. TIMSS requires learners' achievement to be based on their abilities and not to be influenced by other uncontrolled factors. The crucial processes in ensuring internal validity for TIMSS were sample selection, development of instruments and proper administration of the test.

External validity refers to the extent to which the study's results can be generalised to the whole population (Maree, 2016, p. 169). External validity is about whether the results from a study like TIMSS represent the intended population and predict similar constructs. Some factors that could threaten the external validity of TIMSS are sampling procedures and scoring of the constructed response items (Mullis & Martin, 2008). Participant characteristics such as SES, age, gender, race and ability may also affect external validity and the characteristics of the environment in which the data is collected, e.g. surroundings and time of the day (McMillan, 2016, p. 249).

Content validity of the TIMSS instruments was examined during the item development process by subject matter experts to ensure a higher degree of validity of the TIMSS instruments. (Martin et al., 2016; Mullis and Martin, 2013). Items were developed so that all the content areas and cognitive domains specified in the assessment frameworks were covered by the items (Mullis et al., 2016).

A team of subject matter experts in the participating countries developed the items. Every item was classified according to the construct that it intended to measure. Items were also classified according to whether they measured content, or some skill associated with mathematics.

The items had to undergo a series of quality checks by subject experts at national and international levels before they were deemed appropriate. A pool of items was then compiled and approved for field-testing by the items review committee. As already detailed in previous sections, the NRCs did the field testing of a small representative sample of the items. Based on field test findings, the NRC could review and improve the test items to align them to the unique contexts of that country (Martin et al., 2016).

After the field tests, the TIMSS and PIRLS International Study Center experts did an item by item analysis of the field test. Items adjudged to have poor measurement properties, such as being too hard or too easy or failing to separate learners according to ability, were reviewed. Items were also reviewed if it was observed that learners from one country performed differently compared to the international average. This discrepancy could indicate the effect of translations that could have inadvertently changed the item's complexity (Mullis et al., 2016). Items were validated by a group of experts, SMIRC, who scrutinised the instruments for content accuracy, clarity and adherence to frameworks. After the test and curriculum matching analysis was completed, the assessment items were sent to the IEA DPC for approval.

2.14.2 Reliability of TIMSS data

Reliability refers to the extent to which instruments or tools used to collect data, give consistent results if they are used repeatedly (Maree, 2016; Martin & Mullis, 2008). For large-scale assessments like TIMSS to have sufficient reliability, the instruments which are used should be the same. The same environment is created for the use of the instruments, the respondents should answer in the same manner, and the scoring of the instruments should be consistent (Martin & Mullis, 2008). Reliability is about the dependability of instruments to produce the same results when used at different times or places. In studies such as TIMSS that seek to measure trends in mathematics achievement over time, reliability is paramount in ensuring that data from different cycles can be compared and studied. TIMSS assessments are based on the premise that: "if you want to measure change, don't change the measure" (Mullis & Martin, 2013; Mullis et al., 2016). This, in other words, speaks to the importance of consistently using the same instruments to get reliable results.

The TIMSS items are not changed completely from one cycle to the next, but one-half of the items are trend items, maintained for continuity from previous iterations. In contrast, new items are infused to keep up with current topics and technology. Maintaining common items between different iterations of TIMSS ensures reliability since it will allow direct comparisons (Mullis et al., 2016; Mullis & Martin, 2008).

Procedures were put in place to assess the accuracy and consistency of the scoring to monitor and enhance reliability. This was done to ensure a high degree of agreement in scoring between scorers in the same country and scorers in different countries (Foy et al., 2016).

2.14.2.1 Within-Country Reliability

Two independent scorers were assigned to score a random sample of 200 constructed items. The level to which their scoring was close to each other measured the reliability of the scoring process. There was a very high level of agreement between the scorers, with an international average of 96 per cent (Foy et al, 2016; Johansone, 2016; Mullis & Martin, 2008).

2.14.2.2 Trend-item scoring reliability

One of the main aims of TIMSS is to compare learners' performance over time to ascertain whether there are any improvements in learners' achievement (Mullis et al., 2016). It is imperative to ensure that the scoring of the achievement items is the same to compare learners’ achievement between different assessment cycles. Two-hundred items were scanned by the IEA DPC and delivered electronically to all participating countries for remarking to ensure that there was reliability in scoring from one cycle of TIMSS to the next. The scorers for TIMSS Numeracy 2015 were also asked to score the 2011 items to check on the scoring consistency. There was a high level of consistency in the 2011 scores and the scores given by the 2015 assessors. The international average for the consistency was 96% for Grade 4 mathematics (Grade 5 for South Africa) (Foy et al., 2016).

2.14.2.3 Cross-country scoring reliability

Twenty-one items were scored, and then 200 learner responses to each of the 21 items were scored, scanned by the IEA DPC and sent to other participating countries to ensure cross-country reliability and that constructed response items were being scored in the same way in the different participating countries. These items were then independently scored in the other countries, and the degree to which the scores agreed was a measure of scoring reliability across nations. Very high reliability across the scorers in the different countries was reported (Johansone, 2016).

2.15 TIMSS: The South African Design

All the countries that participated in TIMSS 2015 tested their Grade 4 learners except for South Africa, which tested learners in Grade 5. South African learners participated in TIMSS Numeracy, a more accessible and more straightforward version of mathematics designed for learners whose mastery of mathematics is low (Mullis & Martins, 2016). The other countries which participated in TIMSS Numeracy 2015 were Bahrain, Indonesia, Iran, Jordan, Kuwait and Morocco. Table 2.9 shows the application areas where South Africa was different from the international norm.

Table 2.9

The South African TIMSS design

Activity	TIMSS 2015 International	TIMSS 2015 South Africa
Learners tested	Grade 4	Grade 5
Test written	TIMSS Standard	TIMSS-Numeracy
LoLT	Mostly same as the home language	Mostly different from home language

South Africa participated at Grade 9 level in 2015. According to Spaull (2013), the performance of South African Grade 8 learners in TIMSS 1995 and TIMSS 2002 showed that the learners mostly performed at the level of guessing without demonstrating the minimum basic knowledge and understanding of mathematics. It was subsequently decided to use the Grade 9 South African learners in the next iterations of TIMSS (Spaull, 2013). However, the Grade 9 learners still performed poorly relative to learners from most of the participating countries. In following with the tradition of testing learners a grade above the international standard, and when South Africa participated in TIMSS Numeracy 2015, they opted to test learners in Grade 5 to get meaningful results (Mullis & Martins, 2016). South African Grade 5 learners performed poorly, with more than 60% of the learners failing to reach the low benchmark of achievement as set out by TIMSS. Only 1% of the learners managed to score more than 625 points, which is the highest benchmark of TIMSS.

2.16 Summary

Chapter 2 provided an overview of the IEA in terms of its origins and its objectives. The chapter also looked at TIMSS, one of the flagship studies conducted by the IEA alongside PIRLS. The main mission of the studies conducted by the IEA is to gather data about different educational systems around the world and provide rich information about the educational systems with respect to what is going right and areas that might need intervention and improvement. The information gathered also helped to compare educational systems around the world so that the countries not performing well could copy the good practices from those countries doing well.

TIMSS studies also seek to establish the nature and quality of the education system and the different contexts in which learning takes place. South Africa began participating in TIMSS in 1995 at the Grade 8 level, followed by another participation at the same grade in 1999. However, in 1995 and 1999, South African Grade 8 learners performed so poorly that most demonstrated a lacked the minimum basic knowledge and understanding of mathematics. To get some better information, South Africa tested both Grade 8 and Grade 9 in TIMSS 2002. The Grade 9 learners achieved better than the Grade 8 learners but still, overall, South Africa was the lowest-performing country in TIMSS 2002. In TIMSS 2011, only Grade 9 learners wrote the test. In 2015 South Africa participated at Grade 4 level but had the Grade 5 learners write the test. South African Grade 5 learners wrote the TIMSS Numeracy test, which was introduced by TIMSS for the first time in 2015 and was designed for those countries whose learners had a weak knowledge and understanding of the basic concepts in mathematics. TIMSS Numeracy has much easier, straightforward questions, and the results are scaled at the same level as the standard TIMSS test.

The TIMSS conceptual framework is made up of the intended curriculum, implemented curriculum and the attained curriculum. The intended curriculum is what the policymakers envisage the learners to learn, the implemented curriculum is what the teachers deliver to the learners in class, and the attained curriculum is what the learners actually gain from their learning. To best understand what affects learning, it is paramount to understand the different environments the learners experience during their learning process.

For TIMSS Numeracy 2015, the different contexts explored were the national, home, school, classroom and learner contexts. The national context is for setting broad goals and policies as well as coming up with the curriculum. Home contexts entail providing the necessary resources and supportive homes that might help the child learn well. It is the responsibility of parents to offer psychological and emotional support and assist in fortifying the right attitudes in the children. South Africa is a country with massive inequalities, and 70% of the learners come from poor backgrounds. However, South African parents value their children's education and have very high expectations about their children's education. The school contexts in South Africa also lay bare the prevailing inequalities in society. The schools serving the rich are well resourced, while those serving the poor in townships and rural areas are typified by lack of resources and overcrowding. Well qualified teachers in South Africa also tend to shun poorly resourced schools in preference for the well-resourced and functional schools in urban areas. In the classrooms in South Africa, the teachers were reported as being happy about their job, and teacher absenteeism was not a major problem. However, there are teachers in South Africa who lack the requisite content knowledge to teach mathematics.

The instruments used in TIMSS Numeracy 2015 were the learner achievement test, the home questionnaires completed by the parents, teacher questionnaires, school questionnaires completed by the principals, and the curriculum questionnaires completed by the National Research Coordinator. The learner achievement test was made up of multiple-choice questions and constructed response questions. Scorers were trained beforehand to ensure uniformity and consistency in marking, especially the constructed response questions.

This chapter also detailed how it was ensured that the data collected was of the highest quality. The procedures were standardised to ensure consistency. A quality control monitor was appointed in South Africa to monitor the administration of the test in schools. A process that was also closely monitored for quality purposes was the translation of items to different languages, e.g. to Afrikaans in South Africa. Language experts were consulted to ensure that comparability was guaranteed.

Chapter 3
Literature Review and Conceptual Framework

3.1 Introduction

Knowledgeable parents who provide a favourable and supportive home environment to their children aid them to acquire more positive attitudes towards mathematics, which might ultimately lead to better academic achievement (Soni & Kumari, 2015). Children learn from their parents what to value as important or less important (Mohr-Schroeder et al., 2017; Soni & Kumari, 2015). According to Hoover-Dempsey et al. (2005), the home environment lays a solid foundation in a child's education since learning starts taking place long before a child sets foot at a school. For children to value certain things in life, these values should be inculcated early in life and then consistently reinforced at home and at school (Hoover-Dempsey et al., 2005; Jay et al., 2018; Maloney et al., 2015; Mohr-Schroeder et al., 2017; Reddy et al., 2015). According to Jacobs and Eccles (1992), cultural stereotypes may shape parental attitudes and expectations towards the achievement of their children in mathematics, which will affect the child's perception of their abilities. According to Maloney et al. (2015), these stereotypes may include believing that boys are better than girls in mathematics. Parents' attitudes towards mathematics are potentially an accessible and effective area for intervention to reduce learner anxiety in mathematics (Choi & Han, 2020, Maloney et al., 2015). Parents may help by setting and communicating high academic expectations of their children (Yamamoto & Holloway, 2010). Higher parental expectations tend to result in correspondingly high expectations and motivation of the learners (Yamamoto & Holloway, 2010). Learners with high expectations for themselves are more likely to have improved achievement in school than learners who have low expectations (Howie et al., 2017).

Mathematics is a subject that has been long identified as challenging to many learners in South Africa (Spaull, 2013). Ways should be explored in which parents can collaborate with schools to improve mathematics achievement. Past experiences may shape learners' attitudes in mathematics in a particular way, depending on what parents communicated about mathematics perceptions. Parents past experiences with mathematics and fear of failure may affect parents' demands about their children's schooling (Jay et al., 2017). According to Peters et al. (2008), part of the reason parents may view mathematics negatively stems from the fact that parents see a disconnect between the methods they used during their school years and the methods currently employed by their children (Jay et al., 2017).

Parents can demonstrate that mathematics is important by emphasising an interest in their child's progress, checking their schoolwork and assisting them with their homework where possible (Jay et al., 2018; Pritchard, 2004). Parents may also choose to involve their children in home activities that reinforce mathematical skills. The attitudes, beliefs and expectations held by parents towards mathematics determine the parents' level of involvement in the mathematics learning of their child (Mohr-Schroeder et al., 2017). Discrepancies between what is communicated at home and school may create a confusing learning environment for the learner. Therefore, it is important to agree on what is communicated at school and what is reinforced by parents at home about mathematics (Jay et al., 2018; Pritchard, 2004).

This chapter starts by looking at the history of mathematics learning and teaching in South Africa, especially looking at the profoundly segregated education system during apartheid and its potential harm to the attitudes and self-belief of learners towards mathematics. Section 3.2 looks at the history of mathematics teaching and learning in South Africa. Section 3.3 describes the quintile system in South Africa, a system of grouping schools according to the comparative affluence of the neighbourhood in which the school is located. Factors that might be associated with achievement for learners from higher and lower quintile schools are also discussed. The following section, 3.4, explores what has been written about cultural capital and how it gives children from high SES backgrounds an advantage. Section 3.4 looks at the conceptual framework and the different variables included in the current study. Section 3.5 presents the conceptual framework that was used for this study. Parental attitudes, beliefs and expectations and their relationship with achievement are explored in Section 3.5. Finally, the chapter looks at different types of parental involvement which might be related to academic achievement.

3.2 History of Mathematics Teaching and Learning in South Africa

"What is the use of teaching the Bantu child mathematics when it cannot use it in practice? That is quite absurd. Education must train people in accordance with their opportunities in life, according to the sphere in which they live." Dr Hendrik Verwoerd, as quoted in Clark and Worger (2011, p. 55).

The attitudes, beliefs, and expectations exhibited by parents towards their children's mathematics education may be traced back to what transpired during their school days (Jay et al., 2018). Attitudes and beliefs are shaped over time and also due to the prevailing circumstances. It is essential to reflect on the history of mathematics teaching and learning in South Africa to better understand the difference in mathematics achievement between schools. Understanding the context of mathematics over the years could illuminate the differing attitudes, beliefs and expectations that parents have towards mathematics.

South Africa had a deeply segregated education system before the dawn of democracy in 1994 (Mbiza, 2018; Msila, 2007). During apartheid, most Black South Africans were condemned to an inferior education system called Bantu education which was introduced through the Bantu Education Act of 1953. Bantu education was specifically designed to enforce an acceptance of the belief that non-White people were inherently inferior (Clark & Worger, 2011; Schoeman, 2018; Wills, 2011). McKeever (2017) carried out a secondary study using data from the 1991 household survey (Survey of Socio-Economic opportunity and Achievement) to examine the inequalities in educational achievement during apartheid. The sample was made up of 9 086 respondents and was representative of the adult population of South Africa during that time. The survey had questions on income, occupation history and some demographic questions. Analysis of the data showed that parental background affected educational achievement. Respondents whose parents were more educated had better educational attainment. Black respondents had the least chance of having completed secondary education, which could be linked to the fact that their parents were from poor backgrounds with inadequate levels of education.

Respondents whose parents had low education were also least likely to do mathematics and science at secondary school. Respondents whose fathers were in lower-ranking occupational groups had the least chance of attending lower secondary school. It is likely that less educated parents were in the low-ranking occupational groups and were poor, which might have caused their children to drop out of school because of a lack of resources. According to Gustafsson et al. (2011), more educated parents are more likely to have higher academic expectations for their children. They also adjust their expectations according to how their children perform in school. Poor parents either exhibit low expectations about their children's education or, at times, have unrealistically high expectations, way above the levels of performance of their children (Gustafsson et al., 2011). Black South African parents never had the privilege of going further with mathematics and experiencing the opportunities mathematics could offer them, experiences they could share with their children (Mbiza, 2018). However, according to the South African Institute for Race Relations report (2019), nearly 60% of parents in South Africa identify education and job creation as a prerequisite to change life circumstances for the better. The fact that South African parents are aware of the importance of education might make them have more positive attitudes and higher expectations about their children, which are likely to result in increased achievement. There has been substantial improvement in terms of Black African learners' achievement in mathematics at Grade 12 level, with the enrolment into engineering at universities increasing by 65% for the period 2002-2016 (Van der Berg & Gustafsson, 2017)

3.3 Quintile System and mathematics achievement

According to Goodman et al. (2011), children from economically disadvantaged backgrounds exit school with substantially weak achievement, especially in mathematics. The differences in achievement between children from poor backgrounds and those from high SES backgrounds are already large by the time they start school, and this gap continues widening as a child moves up the grades (Goodman et al., 2011; Spaull, 2013). The family SES varies strongly with parental attitudes, aspirations and expectations towards their child's education (Goodman et al., 2011). The absence of positive parental attitudes and aspirations likely leads to the children also having negative attitudes and self-belief in mathematics (Goodman et al., 2011, Mohr-Schroeder et al., 2017). According to Goodman et al., (2011), children from poor families tend to feel as if they are less capable in mathematics, and they are also more likely to consider school results as less important in determining one's future.

One of the legacies of apartheid in South Africa is the lingering inequality in education caused by deliberate segregation policies (Graven, 2014; Ogbonnaya & Awuah, 2019; Spaull & Kotze, 2015). These policies resulted in most Black learners receiving very little funding for their education, while white minority learners received disproportionately more significant funding for their education from the state (Ogbonnaya & Awuah, 2019). As a consequence of this skewed funding, most Black South African learners did not receive quality education because of a lack of resources such as good infrastructure in schools, books and competent teachers (Spaull, 2013). To undo the apartheid legacy, the new South African government categorised schools into groups by the relative wealth of the community where the school is located (Graven, 2014; Ogbonnaya & Awuah, 2019).

The uneven distribution of resources and capital across schools and unequal resourcing of schools contribute to the existence of a dualistic education system. This dualistic system results in large differences in learners' achievement, which can be attributed to differences in wealth, socio-economic status, geographic location, and learners' language (Spaull, 2013). Schools classified as Quintile 1 comprises the poorest 20% of the schools. The next 20% of schools are in Quintile 2, and Quintile 5 has the most affluent 20%. Quintile 1-3 schools are no fee-paying schools since the parents of the learners going to these schools are deemed too poor and cannot afford to pay (Ogbonnaya & Awuah, 2019).

Approximately 60% of learners in South Africa come from poor backgrounds. Spaull (2013), agrees that South African education is a two-tier system with non-fee-paying public schools and low fee-paying private schools forming the first tier. The second tier comprises fee-paying public schools and elite independent schools which charge high fees. The majority of mainly Black and Coloured learners are located in the historically disadvantaged system, and these are in the Quintile 1 to 3 out of the five quintiles (Ally & McLaren, 2016; Fin, 2014). These particularly disadvantaged learners are children in rural areas and townships and children whose home language is different from the LoLT of English and Afrikaans. The Quintile 1 to 3 children would often be found in the poorest and mostly rural provinces such as Limpopo, the North West, Eastern Cape and Mpumalanga (Branson & Zuze, 2012).

Learners in Quintile 1-3 schools typically demonstrate low proficiency in reading, writing and numeracy. They are more likely to be taught by underqualified and de-motivated teachers, receive homework less regularly, are more likely to repeat grades, have fewer resources at school and may not speak the LoLT at home (Branson & Zuze, 2012), 2016; Ogbonnaya & Awuah, 2019). According to Van der Berg et al. (2016), when the curriculum is mainly taught in English, this might cause a barrier to learning for most learners who might not engage with the curriculum because of language. The gap may widen as they move to upper grades. The second sub-system consists of mostly model C schools that historically served white children and have learners achieving levels comparable to the norms of learners in developed countries. These schools are mostly in the Western Cape and Gauteng and fall in the Quintile 4 to 5 system (Branson & Zuze, 2012). This second system caters mainly for white and Indian children, although black and coloured children are increasingly moving to these schools (Spaull & Kotze, 2015). This movement shows that in democratic South Africa, it is no longer race that is the main factor in determining the composition of schools, but the financial wellbeing of the families that the learners hail from (Spaull & Kotze, 2015). One of the major criticisms of the quintile system is the inaccurate classification of schools, resulting in the exclusion of schools that are in relatively wealthy areas but are predominantly serving poor learners from adjacent communities (Ally & McLaren, 2016).

The wide socio-economic inequality plays an exceptionally strong role in determining educational achievement in South Africa. Therefore, if a learner is from a poor background, they are more likely to fail school exit-level subjects (Smith, 2011).

3.4 Cultural Capital and Academic Achievement

Children come to school from different home contexts and cultures. The South African families are diverse in terms of their composition. According to the General Household Survey conducted by Statistics South Africa in 2016, a third of all households are extended families. Extended families are made up of people who are related and staying together, but not a nuclear family. Most of the children in extended families stay with their grandparents or aunts. Nuclear families, with a father, mother and children, made up 19 % of the households. Single parent families where a person lives with their children but without a spouse or partner constituted 11% of the households. Composite families, where at least one member is not related to the others, made up 2% of the households. Two-thirds of children in South Africa came from extended family households, whilst a quarter (25%) came from nuclear families. One in every ten children (10%) came from single parent households (Statistics South Africa, 2017).

Notably, two thirds (66%) of black learners came from extended family households compared to 23% for whites. On the other end, 67% of the whites came from nuclear families compared to only 21% for blacks. The family backgrounds where learners come from vary in terms of SES, language of communication at home, and attitudes, values, and aspirations from their parents, which learners observe and may internalise (Friedman et al., 2016). Most extended families in South Africa are synonymous with poverty and deprivation since, in most of these families, an unemployed grandmother will provide for the children (Munje & Mncube, 2018; Statistics South Africa, 2017). According to Bourdieu (2008), cultural capital in the school context refers to knowledge, resources, skills, education, and other competencies that might give some learners an advantage over others. Often, parents are the sources of cultural capital at home through the transmission of attitudes, values, beliefs, and aspirations necessary for one to excel at school (Spillane et al., 2008). According to Bourdieu (2008), cultural capital has three dimensions: the objectified form, embodied form, and the institutionalised state:

- Objectified cultural capital refers to tangible material resources available at home, giving learners from high SES families an advantage compared to those from low SES families. These material resources may include books, computers, access to the internet, learning facilities, and other resources that make it possible for children from wealthier backgrounds to learn and attain a set of skills, values, perceptions, and knowledge cherished by teachers at school.
- Embodied cultural capital is about the many learner dispositions children get from their home backgrounds necessary for academic achievement. Embodied capital includes values, attitudes and beliefs needed for learning, tastes and preferences for academic quests, and other skills and competencies that are esteemed at school as evidence of capability. Some of the variables that constitute embodied cultural capital may include child and parent academic expectations, attitudes towards learning, cultural participation, and parental involvement at home and school.

- Institutionalised cultural capital results when embodied cultural capital finds expression and is publicly acknowledged and valued as differentiating people in society.

According to Tan et al. (2019), children from high SES families have more cultural capital than children from disadvantaged families. This difference in cultural capital will likely lead to gaps in achievement between the learners. According to Bourdieu's cultural reproduction theory, high SES families wield more cultural capital. The parents transmit this cultural capital to their children, who, in turn, will pass it to their children, thereby leading to another cycle of inequality. This transmission of cultural capital from parents to children results in families with greater cultural capital maintaining their dominant position as teachers and schools tend to be biased towards learners with higher cultural capital, whom they consider more capable. According to Mutekwe (2014), learners from high SES backgrounds possess certain attitudes, beliefs, aspirations and other socio-economic dispositions endorsed by society. This bias may lead to the continued dominance of those with greater cultural capital over those with less cultural capital, even in terms of academic achievement.

Learners coming from high SES families are more likely to have parents who are better educated and may assist their children with homework are involved in more home discussions about school, and likely have higher academic expectations in comparison children from low SES families (Friedman et al., 2016; Tan, 2017). High SES parents are more likely to have gone to the same schools as their children and will know the cultural expectations of the schooling system (mannerisms) which they pass on to their children, thereby giving them an advantage (Mutekwe, 2014; Spillane et al., 2008).

Tan (2017) carried out a meta-analysis on 41 published studies between 1985-2015 investigating the relationship between cultural capital and academic achievement. From the meta-analysis, Tan (2017) observed that cultural capital had a small to medium effect on academic achievement, meaning that there is a positive relationship between cultural capital and academic achievement. Some of the cultural capital factors such as parental expectations and level of parental education were observed to have larger effect sizes showing that they were more associated with academic achievement.

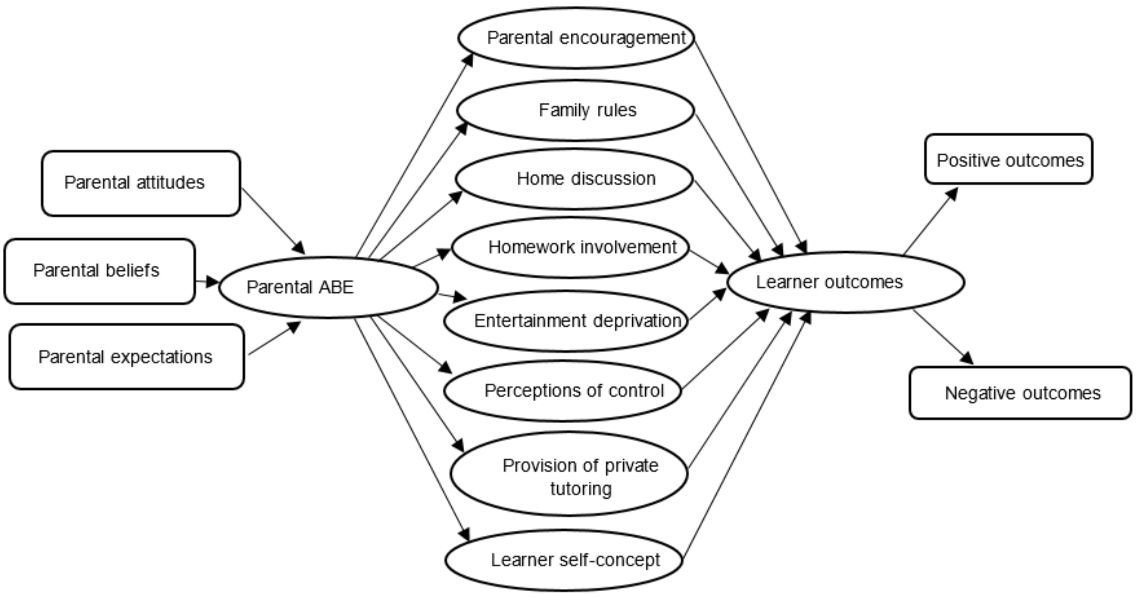
In another meta-analysis study, Tan et al. (2019) used the 150 published studies in 2000-2017 to investigate the cultural type attributes associated chiefly with academic achievement at a given stage of a child's learning. The results showed variables such as parental education, home support, availability of home resources, parental expectations, cultural participation and having positive attitudes towards school benefitted all learners, while some variables showed a differentiated form of association with academic achievement depending on the child's grade. Kindergarten learners benefitted more from the parental level of education, parent-child reading and the value the parents placed on education. Learners in Grade 7-12 benefitted more from academic discussions between parents and their children than Grade 1-6 learners. Parental involvement tended to benefit kindergarten learners and learners in Grade 7-12 than those in other grades.

3.5 Conceptual Framework

This study is based on the conceptual framework by Weerasinghe (2016a) that looked at connections between parental attributes (parental attitudes, parental beliefs and parental expectations), which are collectively referred to as parental ABE, factors of parent involvement and student outcomes. In this study, student outcomes are going to be referred to as learner achievement.

Figure 3.1

Conceptual Framework



Adapted from Weerasinghe (2016a)

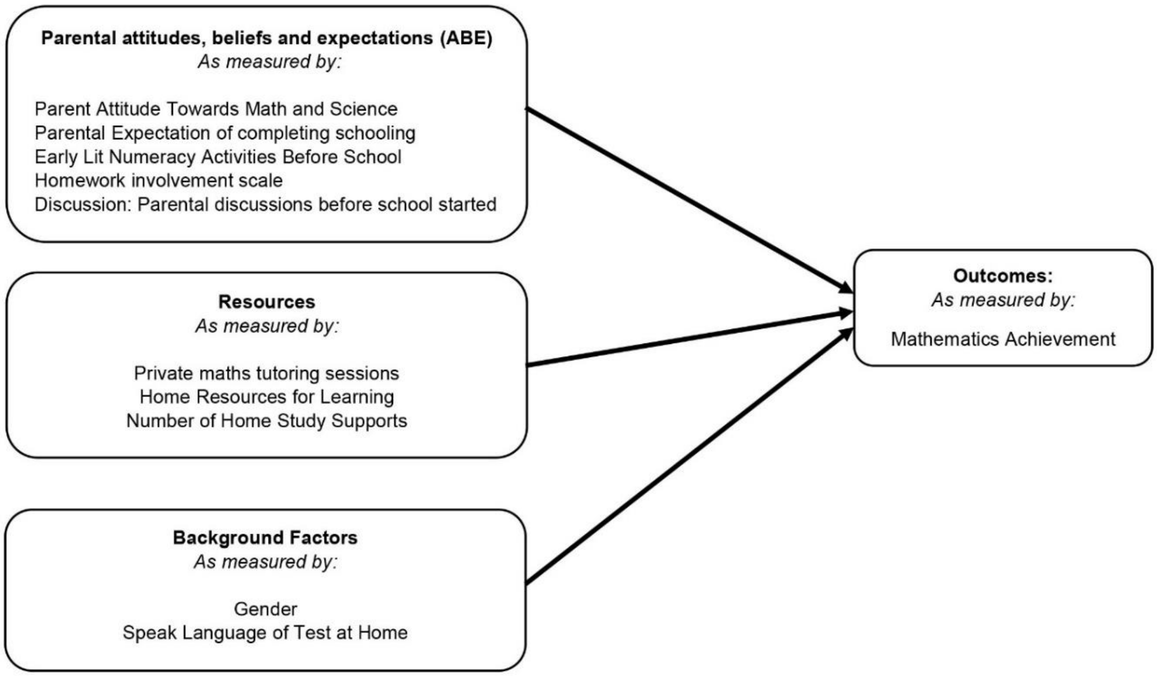
From the conceptual framework in Figure 3.1, the independent variables utilised in the current study include parental attitudes, beliefs and expectations (ABE), parental encouragement, home discussion, homework involvement, and private tutoring. The dependent variable is learner achievement, the learner's score in the TIMSS 2015 mathematics test. For this study, private tutoring refers to any lesson conducted outside the normal school hours. Parental encouragement, home discussion, homework involvement, and private tutoring were fixed factors and not used as mediating factors. The simplified version of the conceptual framework containing the variables of interest is shown in Figure 3.2. As shown in the figure, parental attitudes, beliefs and expectations were measured by:

- Parent Attitude Towards Math and Science
- Parental Expectation of completing schooling
- Early Literacy and Numeracy Activities Before School
- Homework involvement scale
- Parental discussions before school started

Resources included the private maths tutoring sessions and their frequency, home resources for learning and the number of home study supports. Due to the multilingual nature of South African classrooms, speaking the language of the test and frequency of use thereof were also included.

Figure 3.2

Conceptual Framework – simplified version to reflect current study



Adapted from Weerasinghe (2016a)

Variables not included in this study are family rules, entertainment deprivation, perceptions of control and student self-concept (see Figure 3.1). These factors do not have corresponding measures in any of the TIMSS 2015 background questionnaires. Using the selected variables will give a comprehensive indication of parents' role as they cover crucial aspects of the model. The variables which are excluded do not weaken the modelling as they are sub-domains of the main variables.

3.6 Parental Attitudes, Beliefs and Expectations

Parental attitudes, beliefs and expectations and their connection with a child's academic achievement is an area with extensive literature cover (Mohr-Schroeder et al., 2017; Pritchard, 2004; Soni & Kumari, 2015; Weerasinghe, 2019). Parental attitudes, beliefs and expectations are positively associated with academic achievement (Howie et al., 2017; Maloney et al., 2015; Mohr-Schroeder et al., 2017; Yamamoto & Holloway, 2010). According to Khan and Zahidullah (2017), attitudes are the perceptions or evaluations that people create after interacting with objects, ideas, events or other people. Attitudes may be positive or negative (Khan & Zahidullah, 2017). Positive parental attitudes may help reduce the anxiety of learners towards mathematics. Most children spend a considerable amount of time with their parents/guardians as they grow up, and they directly interact with parents' thoughts, values and beliefs. Parents' attitudes may be more likely to be transmitted to their children through their daily interactions (Choi & Han, 2020, Maloney et al., 2015). The most effective way to foster a positive attitude in school is for the parents to have a positive attitude towards the school Robinson & Harris, 2014, Mansour & Martin, 2009; Mohr-Schroeder et al., 2017) and in turn, for parents to have high expectations of their children (Robinson & Harris, 2014; Yamamoto &Holloway, 2010). According to Durisic and Bunijevac (2017), parents who hold high expectations about their children's academic achievement are likely to be more eager to provide the necessary support to their children to ensure that those expectations are met.

Using the PIRLS 2011 data, Howie et al. (2017) reported that parents play an important role in modelling reading behaviour for their children. Parents who promote a reading culture in the home environment motivate children to be good readers. Children whose parents liked reading had children who tended to achieve better reading scores than the learners whose parents did not like reading (Howie et al., 2017). Juan and Visser (2017) analysed the TIMSS 2011 data to investigate the home and school factors associated with science achievement. Their results showed that learners from environments where their parents valued science were more likely to score higher in science.

Some studies have specifically investigated the link between parental attitudes, beliefs and expectations and academic achievement in mathematics. Areepattamanil et al. (2015) conducted a study investigating the link between parental attitudes towards mathematics and mathematics achievement in the United Arab Emirates. Using data drawn from the fifth cycle of the Program for International Student Assessment, (PISA), a multi-level regression analysis was carried out and the results showed that those learners who perceived their parents as people who valued mathematics and liked the subject, had statistically higher levels of motivation towards mathematics. Learners with parents who valued mathematics and considered the subject as important had children who showed higher intrinsic motivation and higher work ethic than those whose parents had negative attitudes towards mathematics.

Maloney et al. (2015) carried out an extensive field study on learners in the first and second grade to investigate how the parents' level of anxiety in mathematics is related to their children's mathematics achievement. Descriptive statistics were used to analyse the data. The results showed that the parent's mathematics anxiety was negatively associated with the child's achievement in mathematics, especially in situations where the parents helped their children with homework. Children whose parents were anxious about mathematics were more likely to develop negative attitudes towards the subject, which likely affected their achievement in the subject.

Choi and Han (2020) carried out a meta-analysis of seven studies investigating the relationship between parental attitudes towards mathematics and their children's mathematics anxiety. The results showed parental attitudes towards mathematics were inversely proportional to learner anxiety. The drawback with the studies used in the meta-analysis is that they used different instruments to measure mathematics anxiety and parental attitudes, making it difficult to compare them. The studies used in the meta-analysis did not measure the anxiety of learners in similar or close grades, which might be a problem since anxiety towards mathematics is likely to differ when a learner moves from one grade to the other. Five of the seven studies focused on college learners, with only one analysed for the middle school and foundation stage, respectively.

In a 2017 study, Mohr-Schroeder et al. investigated parents' attitudes towards mathematics and how they related to learner attitudes about mathematics. A quantitative survey design, descriptive statistics, and regression analysis were used to analyse the data. The results of this study showed that most parents had positive attitudes about mathematics. The results also showed a statistically significant positive correlation between parents' attitude towards mathematics and the learners' attitudes towards mathematics. Khan and Zahidullah (2017) investigated the relationship between parents' attitude towards mathematics for girls and the girl child's attitude towards mathematics as perceived by the parents in government girls' colleges in Pakistan. Khan and Zahidullah (2017) used a qualitative research approach in which data was collected through interviews. The results showed that parents had a negative attitude towards the girl child pursuing mathematics at school. Many parents did not see the value in girls doing mathematics, and they discouraged their girl children from doing mathematics since they considered mathematics to be a male domain. However, the qualitative research used by Khan and Zahidullah (2017) does not generalise the results to different contexts.

In another study, Soni and Kumari (2015) investigated the role of parental attitudes towards their children's mathematics achievement. Their participants were learners aged between 10 to 15 years and their parents. The results showed that the fathers' mathematics anxiety was positively related to the son's mathematics anxiety towards the subject, and the mother's anxiety was positively related to the daughter's mathematics anxiety.

In a 2014 study, Perera, Bomhoff and Lee investigated the extent to which parental attitudes towards science (in terms of how much they valued science and the importance they attached to science as a subject) was related to their children's achievement (Perera et al., 2014). Data from the PISA 2006 survey was used. Hierarchical Linear Modelling was used to analyse the data, and the results showed a positive association between the parent's attitude towards science and their child's achievement in science. The other important result of this study by Perera et al. (2014) was that learners from disadvantaged backgrounds seemed to benefit from parental attitudes in much the same way as learners from high SES backgrounds. Madhubala and Bhuvaneswari's (2016) study determined the relationship between parental expectation and learners' academic achievement in secondary school. A survey method was used, and the data was analysed by t-test and linear regression. The results showed that there was no significant relationship between parental expectation and achievement for secondary school learners. Unlike those in primary school, learners in secondary school tend to want more independence from their parents and do not like it when their parents try to foist their preferences on them (Madhubala & Bhuvaneswari, 2016). Knap et al. (2016) investigated the connection between parental attitudes and learner achievement in mathematics. The participants in the study were parents, teachers and learners in Grade 4 up to Grade 8 from different races. The parents, teachers and learners were involved in a programme, called Math and Parent Partners (MAPPS). A mixed-method study with a quasi-experimental design was used. The participants completed an attitude survey which was analysed using paired sample t-tests. The results showed that if parents were actively participating in the MAPPS programme, their children perceived their participation as a sign that the parents valued mathematics. The learners derived motivation from seeing their parents showing interest in attending the MAPPS programme. An increase in parental attitudes was related to higher motivation for the learners, which was associated with higher achievement in mathematics.

In a study on parental expectations, Yamamoto and Holloway (2010) reviewed research done on the relationship between parental expectations and learner achievement within and between different ethnic groups. Twenty-one studies on parental expectations and learner achievement were reviewed. The result showed a mixed bag, with some studies reporting a positive association between parental expectations and learner achievement for all ethnic groups, while other studies showed that the relationship tended to depend on the ethnic groups. Therefore, it is likely that parental expectations affect learner achievement through different mechanisms which vary between ethnic groups (Yamamoto & Holloway, 2010). One of the mechanisms suggested was effective and intensive parental involvement in their children's education. However, Madhubhala and Bhuvaneswari (2016) studied the relationship between parental expectations and academic achievement in secondary schools. A survey method was used for the study, and data was analysed using t-tests and correlation coefficients. The results indicated that there was no significant relationship between parental expectations and academic achievement.

There has been a shortage of literature about the relationship between parental ABE and learner achievement in South Africa. South Africa has consistently been performing poorly in mathematics in Southern Africa and the rest of the world (Spaull & Kotze, 2015). Therefore, it is important to investigate whether South African learners' poor achievement in mathematics is related to their parents' attitudes, beliefs, and expectations.

3.7 Parental Involvement

According to Durisic and Bunijevac (2017), parental involvement in the child's education commences at home with the parents providing a safe, healthy and enabling environment, some vital learning experiences, material and emotional support and positive attitudes towards school. There have been poor levels of parental involvement reported in academic matters in South Africa, especially from the Black South African parents. Some of the reasons relate to parents' negative attitudes and inferior feelings (Mmotlane et al., 2009). Poor and working-class parents may not have enough time to spend with their children because they work longer hours to support the family. Parents leave very early in the morning to go to work and come back late in the day. Most of the time, the parents will come back from work tired and may not have the time and energy to interact with their children (Machebe et al., 2017). Learners from affluent families may suffer neglect by their parents, who are very busy because of their occupational demands (Ridley, 2017). Children are left under the care of nannies or put in day-care centres because affluent families stay mostly as nuclear family where there is little support from other relatives. Lack of quality time with parents may cause some psychological damage to young children. Successful parents are more likely to exert too much pressure on their children for them to succeed, thereby putting them under immense pressure (Ridley, 2017). Positive parental attitudes towards mathematics and high parental expectations of their children's academic achievement may help stimulate parental involvement in their children's education (Jay, 2018; Knapp et al. 2016; Mohr-Schroeder et al., 2017; Pritchard, 2004; Yamamoto & Holloway, 2010). According to the Department of Basic Education (2017), when parents become more involved in the education of their child, then there is likely to be an improvement in the child's learning. When children know that their parents are involved in their education, they are more likely to work harder, become more committed, and tend to be more attentive to their studies, making them more cognitively competent (Weerasinghe, 2019).

Parental attitudes and expectations need to be put into observable practices for children to benefit from them, for example, parents becoming more involved in their children's learning (Robinson &Harris, 2014; Perera et al., 2014; Pritchard, 2004). Parents must consistently show positive attitudes towards mathematics to positively influence their children's attitudes (Choi & Han, 2020). Many studies generally indicate a positive association between parental involvement and academic achievement (Cai et al., 1999; Muchuchuti, 2015; Mutodi & Ngarande, 2014; Silinskas & Kikas, 2019, Rowan-Kenyon et al., 2012). Parental involvement is more likely to be successful when parents have active and ongoing participation in the learning of their children (Caño et al., 2016; Department of Basic Education, 2017; Hoover-Dempsey et al., 2005; Mutodi & Ngarande, 2014). According to Robinson and Harris (2014), there are three strategies in which parents can be involved in their children's education and create a positive attitude towards school. Parents needed to:

- Share their own experiences about school in terms of what worked well for them and what things they could have done differently;
- Have high expectations for their child in school and communicate these expectations to the child, and
- Foster a growth mindset, a belief that one can incrementally become better in school by putting in more effort.

Parental involvement may be divided into two broad categories: home-based and school-based involvement (Mohr-Schroeder, 2017). Jay et al. (2018) divide parental involvement into parent-centred and school-centred approaches. The home-based or parent-centred type of parental involvement entails the situation where parents are actively involved in their children's learning through their own initiated programmes and activities. These activities may include encouragement through home discussions about mathematics and some home activities, which may help foster mathematics learning. These home activities may also help complementing and consolidating what the children would have learned at school (Jay et al., 2018; Mohr-Schroeder, 2017; Muir; 2012). The other form of parental involvement is school-based or school-centred, where tasks are sent from school for learners to be helped at home by their parents, for example, homework. School-centred parental involvement may also include meetings or activities organised at school where parents are invited to attend parent-teacher meetings, school governing body meetings, or sporting activities (Jay et al., 2018). Parents with positive attitudes and beliefs together with higher expectations towards their children's education tend to be more involved in both home-based and school-based parental involvement than parents with negative attitudes and low parental expectations (Hoover-Dempsey et al., 2005; Jay et al., 2018; Knap et al. 2016; Mohr-Schroeder et al., 2017; Muir, 2012).

The SES of the parents, when coupled with positive attitudes and high expectations, may be associated with higher mathematics achievement for the children (Caño et al., 2016; Mansour & Martin, 2009; Mmotlane et al., 2009; Perera et al., 2014). High SES parents who have positive attitudes are more likely to invest more time and resources towards their children's education and help children with their mathematics tasks and homework than economically disadvantaged parents (Perera et al., 2014; Reddy et al., 2015). Parents of high SES are also more likely to be better educated, and, as a result, they have the content knowledge and competencies in mathematics which are required to assist their children in mathematics. In contrast, low SES parents might not have the necessary time, content knowledge and skills in the subject (Caño et al., 2016; Hoover-Dempsey et al., 2005; Juan & Visser, 2017; Muchuchuti, 2015). Low SES parents are likely to have experienced challenges with mathematics when they were still at school (Perera et al., 2014). However, learners from low SES backgrounds may derive the same benefits from more positive parental attitudes as those from high SES backgrounds (Robinson & Harris, 2014; Perera et al., 2014). If low SES parents attach value to mathematics and communicate the importance of mathematics to their children, it may inspire them to achieve better (Robinson & Harris, 2014; Mohr-Schroeder et al., 2017; Perera et al., 2014; Reddy et al., 2015).

3.8 Types of Parental Involvement

Parental involvement is a multi-faceted construct, and may take different forms (Mutodi & Ngarande, 2014). According to Epstein (2002), these may be classified into six broad categories, which are:

- Parenting-parents, providing a conducive environment and the necessary resources which may enhance learning,

- Communicating-opening communication channels between learners, schools and parents so that everyone knows about what is happening in the child's education;
- Volunteering-participating in school-sanctioned events like parent-teacher meetings and other activities which are designed to support and enhance learning;
- Learning at home-schools and parents communicating in a way that will enable the child to continue with learning at home but being supported by parents in doing homework and other home activities;
- Decision-making parents actively participating in the school management and decision making, which help in the smooth functioning of the school; and
- Collaborating parents, communities, and schools combine efforts to raise the resources needed by the school to ensure that school programs continue to run.

This study investigates parental attitude, beliefs and expectations, as measured by aspects of parental involvement in the form of parental encouragement, home discussions, homework involvement and provision of private tutoring.

3.8.1 Parental encouragement

According to Lawrence and Barathi (2016), parental encouragement is the process parents undertake to initiate and direct their children's behaviour towards high academic achievement. Parents may want their children to achieve more success than they had; hence, parents may be willing to work hard and provide the necessary resources for this to happen (Areepattamannil, 2010; Lawrence & Barathi, 2016; Rowan-Kenyon et al., 2012). According to Lawrence and Barathi (2016), "parental encouragement is the inspiration, or the extra-boosting given by parents to the children for their active involvement in academic life". Parental encouragement can be gauged by the frequency with which parents praise their children for doing well or putting in an effort in at school (Areepattamannil, 2010). Rowan-Kenyon et al. (2012) found out that parental encouragement increases the probability of a child doing well in mathematics, especially when rewards and punishment are promised.

Research has established parental encouragement to be a significant factor that determines academic achievement (Areepattamannil, 2010; Singh, 2016). Parents should have a keen interest in their children's education and be actively involved in providing them with sufficient encouragement for them to realise their dreams (Singh, 2016).

3.8.2 Home discussions

Parents may also guide their children in terms of career choices and what is needed for one to pursue a particular career. Since children are likely to attach value to what they perceive their parents to value, parents need to have positive values in mathematics and be in a position to clearly communicate these values to their children (Department of Basic Education, 2017). Children need to know why it is important to do well in mathematics and why mathematics is an important subject (Jay, 2018). According to Jay et al. (2018), the lived experiences of parents may be crucial in giving children some real-life context from which to learn. It is paramount for parents to share their own experience with mathematics when they were in school with their children, in terms of what worked well for them and where they think they could have done better (Durisic & Bunijevac, 2017; Jay et al., 2018). Parents may also discuss the opportunities that mathematics opened for them and missed opportunities due to them not having achieved well in mathematics (Perera et al., 2014). Having these discussions will help demonstrate in real terms how mathematics may change someone’s life in terms of opening up opportunities. According to Perera et al. (2014), when properly communicated, positive parental attitudes and high expectations will help both children from disadvantaged backgrounds and those from high SES backgrounds. Home discussions may also help debunk some cultural stereotypes, for example, the belief that girls are weaker in mathematics than boys.

According to Kormanik (2012), parents may support their children’s mathematics learning at school by making mathematics a more practically relevant subject through the use of mathematics at home. Activities that are done at home help in re-enforcing and complementing the work covered in the classroom. Parents may engage their children in activities that use mathematical concepts directly or indirectly. What learners can learn, observe, discover, and use outside the classroom will likely benefit them as they will understand it more than what they learn in a classroom (Kormanik, 2012, Uscianowski, 2018). Parents may help by playing different types of games with their children; for example, a game of darts will help in addition and subtraction, chess helps in prediction, and critical thinking and a game of poker can help with probability (Kormanik, 2012). According to Isdale et al. (2017), parents playing games involving numbers or letters of the alphabet will result in learners achieving better in mathematics. Parents may also help by discussing what their children did at school and finding its practical application. Parents may read the news with their children and discuss the statistics always presented in the news, which should be analysed with a critical eye (Kormanik, 2012). These discussions will help in consolidating the child’s understanding of graphs, percentages and frequencies.

3.8.3 Homework involvement

Homework is one type of academic engagement that may help bring out the relationship between effort and achievement and, more broadly, the realisation of formal learning purposes. Parents play an important role in inculcating the fundamental dispositions and attitudes necessary for their children to succeed academically and conscientise their children about the role they have to play as learners (Adamuti-Trache et al., 2007). Fernandez-Alonso et al. (2016) noted that parents with positive attitudes and beliefs towards mathematics are very likely to be involved with their child's mathematics homework, monitoring whether the homework is done and helping their children with the homework. One form of parental involvement with inconclusive findings about its relationship with mathematics achievement is helping with homework (Moroni et al., 2015; Weerasinghe, 2019). Some studies have shown the existence of a positive relationship (Maloney 2015; Robinson & Harris, 2014; Weerasinghe, 2016b), while others reported a negative relationship, especially in mathematics (Fan & Chen, 2001; Moroni et al., 2015; Pomerantz et al. 2007; Robinson & Harris, 2014).

Jay et al. (2018) point out that parental homework involvement is directly related to mathematics achievement for the learner if the parents are directly involved with the content of the homework. However, there is a negative association between parental involvement in homework and mathematics achievement if the parental involvement only takes the form of parents monitoring whether homework is done or not (Jay et al., 2018). Jay et al.'s (2018) study contradicted those by Cai et al. (1999), who conducted a study to investigate parents' roles in their children's mathematics learning and to find out if there was a relationship between parental involvement and mathematics achievement. Parents had to complete a Parent involvement Questionnaire (PIC), which looked at five different types of parental involvement: motivating, resource provision, monitoring of schoolwork, advising with mathematics content, and counselling. The results showed that all five types of parental involvement were positively associated with mathematics achievement. However, the three types of parental involvement which showed the most significant association with mathematics achievement were parents motivating their children, resource provision and monitoring of schoolwork. Cai et al. (1999) showed that if parents are not directly involved in learners work but play a supporting role, this may lead to greater mathematics achievement for their children. Núñez et al. (2015) observed that parenting styles might play a part in how learners benefit from homework. Authoritative parents provide more support and will assist directly with homework when asked by their children.

In contrast, authoritarian parents will demand to see and check whether homework has been done. They will also involve themselves directly in the homework without the children asking for assistance and are more likely to take punitive measures against their children if the homework is not done (Dummont et al., 2014; Núñez et al., 2015). An authoritative parenting entails setting high demands for children while giving the children emotional warmth and support (Adamuti-Trache, 2007; Caño et al., 2016).

Silinskas and Kikas (2019) investigated the longitudinal relationship between learners' perceptions about their parents' homework involvement (in terms of control and support) and their achievement in mathematics. Homework control (authoritarian parenting style) was found to be negatively associated with achievement, while homework support (authoritative parenting style) was positively related to achievement.

Some parents may find it too daunting to be involved in supporting their children in mathematics compared to other subject areas like reading and writing due to their own limitations in the subject (Jay et al., 2018, Silinskas & Kikas, 2019). These limitations might include lack of interest and negative attitudes by parents towards mathematics, poor content knowledge of the subject, and not knowing the importance of mathematics as a subject (Jay et al., 2018; Peters et al., 2008). According to Jay and Xolocotzin (2012), many parents want to support their children's mathematics learning but are hampered by a lack of confidence in their ability. However, Tan (2017) notes that as long as parents have positive attitudes towards mathematics, they may circumvent their challenges with mathematics to give their children the necessary support needed to perform well in mathematics, for example, finding them some private tutors. Parents from low SES may not have time or content knowledge to help their children. Still, if they have positive attitudes towards mathematics, they might not need to be actively helping with homework but may just need to show those positive attitudes to their children (Choi & Han, 2020).

Parents may help their children better with their homework if there are better lines of communication between the teachers at school and the parents (Jay et al., 2018). According to Muir (2012), there should be good communication between teachers and parents to ensure that there is congruency in the methods that teachers and parents use. Using similar methods will help prevent the tension that might arise when the parents use methods different from what the learners use at school (Muir, 2012). Parents are more inclined to do mathematics using the methods they used when they were in school, which might differ from their children's current methods. There is a need for teachers to communicate with the parents about how they can work together to help the children with homework at home (Muir, 2012; Pritchard, 2004). The parents should be involved in some programmes which will help boost their confidence in mathematics as well as equipping them with some basic content knowledge so that they could assist their children with homework (Muir, 2012)

3.8.4 Provision of private tutors

Parents with high expectations for their children’s mathematics achievement are more willing to invest in their children, such as paying for private tutoring (Guill & Lintorf, 2019; Lee, 2013). Parents hire private tutors to supplement the teaching and learning happening at the conventional school and increase their children's chances to pass (Cole, 2016; Guill & Lintorf, 2019; Subedi, 2018). According to Guill and Lintorf (2019), private tutoring refers to any teaching activities done outside school hours offered for a fee. After normal working hours, any remedial classes conducted at school do not form part of this definition (Guill and Lintorf, 2019). According to the Centre for Development Enterprise (CDE) (2013), many South African parents are hiring private tutors to augment the learning happening at school. However, some scholars have noted that the provision of private tutors leads to those learners from high SES families having an advantage over the poor and disadvantaged learners whose parents may struggle to afford to pay for such services (Cole, 2017; Guill & Lintorf, 2016; Lee, 2013; Subedi, 2018). According to Cole (2017), the idea of private tutoring results in the reproduction of inequality since the poor will not be able to afford to give their children fair access to good quality education.

The relative effectiveness of private tutoring is a subject of debate (Centre for Development Enterprise, 2013; Cole, 2017). According to Guill and Lintorf (2019), private tutoring is positively associated with mathematics achievement. However, Cole (2017) found a negative and insignificant relationship between private tutoring and mathematics marks after accounting for the differences in academic achievement which existed before the private tutoring was done. Cheo and Quah (2005) carried out a multiple regression analysis with learners in Grade 8 in Singapore as participants and found an insignificant relationship between mathematics achievement and having a paid tutor.

3.9 Critique, Synthesis and Gap in the Literature

Most of the literature indicate a positive relationship between parental attitudes, beliefs and expectations with mathematics achievement. However, no study was obtained that specifically examined the relationship between parental ABE and mathematics achievement in South Africa. Most studies focus mainly on the relationship between school factors (teacher, classroom and resources) and achievement and not at the home circumstances of the learners. The South African context is much more complex than what is found in the developed countries where most of the literature originate. South Africa has one of the highest inequalities in the world. The majority of learners in South Africa come from impoverished backgrounds and rely mainly on the state for their education. South Africa is also still grappling with the legacy of apartheid, where schools in townships and rural areas are almost dysfunctional. The quality of education that a learner is likely to get depends on how wealthy their parents are, where that child was born, and their skin colour (Ally & McIlaren, 2016; Amnesty International, 2020). There is a stark disparity in mathematics achievement at the Grade 12 level, where the top 3% of schools produce more distinctions in the subject than the remaining 97% of schools combined (Amnesty International, 2020). The majority of South African learners use a language of learning and teaching which is different from the language they use at home, which puts them at a disadvantage. With all the challenges faced by the majority of the learners, it may be crucial to examine if mathematics achievement is linked to affective factors such as parental attitudes, beliefs and expectations, which are not expensive to have.

3.10 Summary

Chapter 3 detailed literature regarding parental values, beliefs, and expectations towards mathematics and how they relate to academic achievement. There is a general consensus that parents play a central role in their children's education since they begin learning at home long before they set foot in school. South Africa’s history of deeply segregated learning under apartheid had a negative bearing on the attitudes and beliefs of the Black South African people towards mathematics. While systemic and policy factors added to negative attitudes of Black parents, positive attitudes and expectations can reasonably occur today (maybe because of improved educational access for children, family structures and SES) regardless of race. Since 1994, the government has availed funding for pro-poor policies and also made deliberate interventions to narrow the gap in achievement between learners of different races and socio-economic backgrounds

Studies suggest the existence of a nexus between family SES and the academic achievement of learners in mathematics. Learners from low SES families are likely to attend low quintile schools, which are likely to be characterised by overcrowding, poor infrastructure and a shortage of qualified and experienced teachers (van der Berg, 2008). Learners from poor backgrounds also lack the requisite cultural capital needed to achieve better at school compared to those learners from high SES families who have a head start (Juan & Visser, 2017). The lack of cultural capital from learners from poor backgrounds mainly emanates from the fact that they will be trapped in a generational poverty trap passed from one generation to another. Low SES families may bridge the influence of low cultural capital on their children’s academic achievement by having positive attitudes and beliefs and being actively involved in supporting their children in their schoolwork. Parents who are supportive help demonstrate to their children how they value education, which may ultimately persuade the child to develop some positive attitudes towards school, making the child put more effort into schoolwork.

Chapter 4
Research Design and Methodology

4.1 Introduction

The current chapter describes how the South African TIMSS Numeracy 2015 data were used for secondary analysis purposes. Sections 4.2 and 4.3 detail the research methods used and the advantages and disadvantages of the chosen research methods. The research design for the current study is explained starting from Section 4.4, where the research paradigm chosen for this study is explained. Section 4.5 describes the secondary data analysis and its advantages and disadvantages. Sections 4.6 to 4.10 describe the data collection methods in terms of the participants for the study, sample size, and the instruments used. Section 4.11 to 4.14 explain the data analysis methods that were used in this study.

4.2 Quantitative Research as it Applies to the Current Study

Quantitative research is the type of research which "assumes that phenomena should be studied objectively to obtain a single truth or at least a reality within known probabilities, with an emphasis on measurement, numerical data and experiments" (McMillan, 2016, p. 11). Quantitative research seeks to gather data from a selected population subgroup and generalise the findings to the whole population (Maree, 2016). In other words, quantitative research allows the researcher to investigate a carefully chosen probabilistic sample and use the information collected to make inferences about the whole population. According to Rahman (2017), quantitative research seeks to categorise the social world into measurable components called variables, which can be represented as frequencies and whose relationships with each other may be investigated, measured and generalised.

The research process needs to be as objective as possible (Bird, 2020). For a study to be objective, it should be done to increase the likelihood of reaching true conclusions at the end. The ways that may increase objectivity include the selection of research participants, the sample size, data collection methods and instruments used, and the reporting of the findings (Pandey, 2014). Objectivity may be enhanced by using measurement instruments that are valid and reliable and through the use of standardised data collection procedures (Bird, 2020). Objectivity entails the independence of the data and results from the values and personal judgement of the researcher. Researchers should aim to faithfully represent the data they gather and not distort it through their own prejudices and biases (Bird, 2020; Pandey, 2014).

Different societies have different values and beliefs, and a researcher coming from a society brings those values to the research (Pandey, 2014). According to Bird (2020), to ensure objectivity, a researcher should treat the research methodology as a public account because research is conducted to be critically reviewed by people who share similar or different views and values to the researcher. According to Bird (2020), these public accounts should be honest, reciprocal and rational.

As a public account, a research report is deemed to be honest and truthful if what came out of the study is not twisted or altered in any way (Bird, 2020). A researcher should be honest with how the information was obtained and reported and not try to distort the findings to support or dispute some theoretical narrative. Reporting truthfully on research findings may help to improve the objectivity of the study. Being truthful and honest also entails the researcher acknowledging their research's limitations and bearing in mind that the research findings are just a probable explanation of a phenomenon and not the reality (Bird, 2020, Pandey, 2014).

Research findings should be reciprocating public accounts which allow for a transaction between the researcher and other people who will read the findings. The research results are addressed to people who might agree or disagree with the findings and whose criticisms should be embraced constructively. These criticisms may help the researcher look at the research process and findings in a different way and hence may help improve the objectivity of the research by ensuring that results about research are a true reflection of what was under study (Bird, 2020).

Research outputs, as public accounts, ought to be rational (being intelligible and reasonable), which may allow other people to understand, engage, interrogate, criticise or agree with research findings. Rational reports allow for robust communication and exchange of ideas among people who agree or disagree with the research findings. Objectivity may be enhanced by accommodating other people’s concerns and criticism and being flexible to new ideas and corrections (Bird, 2020).

Common quantitative research methods include descriptive research, correlational research and experimental research (McMillan, 2016). Descriptive research focuses on obtaining overall summaries of data from a sample. Correlational research allows the researcher to investigate any statistically significant relationships between the variables under study. Experimental research is about systematically examining if there are some cause-and-effect relationships between variables.

Quantitative research allows for the direct comparison of studies done in different cultural settings, contexts and with a different set of participants. The use of quantitative research also has the advantage of large, randomly selected samples whose data is analysed through reliable and consistent methods.

4.3 Survey Research

For this study, survey data were used. According to McMillan (2016), survey research is a non-experimental design where questionnaires or interviews are used to gather information from a population or sample. Using survey research enables a researcher, among other things, to collect information about how people live, their attitudes, beliefs, perceptions, language, economic activity, number of resources at home and gender (Maree, 2016).

The advantages of doing survey research include that it is versatile and can address a wide range of problems, especially regarding describing a large population's attitudes, beliefs, and perspectives (McMillan, 2016). Survey research also has the advantage of the findings being generalisable to the entire population through probability sampling.

There are some disadvantages associated with using survey research. Firstly, the respondents may not provide accurate and honest responses. Respondents may tend to answer questions in a “socially acceptable way” instead of giving authentic responses. Secondly, survey research may result in missing data since respondents may feel uncomfortable answering questions that they deem to be sensitive. The non-response to some questions may lead to bias. Thirdly, there is no way to ascertain that the respondents are not being helped by someone else to answer the questions since completing the questionnaires is often done in the absence of the researcher at a time and places convenient to the respondent (Maree, 2016; McMillan, 2016).

Survey research was utilised to collect TIMSS 2015 mathematics and science achievement and background data used for the current study. The parents of participating Grade 5 learners were requested to complete a questionnaire that asked about the home context (Isdale et al., 2017). Information from surveys enables research to be conducted to establish how the circumstances learners live in may be related to their achievement. In this study, the information collected in the survey enabled the investigation of the relationship between parental attitudes, beliefs and expectations and learner achievement (McMillan, 2016).

4.4 Post-Positivism Paradigm as Used in This Study

A paradigm is a theoretical view that forms an important part of the study methodology, and it helps guide the research process (Maree, 2016). Post-positivism is a research tradition that occupies the continuum between positivism and constructivism (Hammersley, 2019). Post-positivism evolved from positivism due to the reactions of researchers in social sciences seeking to improve the research process by collecting more information (Panhwar et al., 2017). The ontology of post-positivism is critical realism, which asserts that all knowledge is fallible but not equally fallible. Critical realists believe that there is a reality independent of our thinking that science can explore (Maree, 2016). However, for post positivists under critical realist ontology, objectivity is an ideal that is not obtainable, but every researcher should strive to attain it.

According to Bird (2020), researcher objectivity may be enhanced through how the research findings are communicated to the public. The research findings are objective in that they cater to different people, some who might share the same values with the researcher and others who might not. When working qualitatively, post-positivists believe that researchers are subjective but that the subjectivity can be negated through peer review and triangulation of results (Henderson, 2011). Triangulation enables researchers to get a clearer indication of reality, although that reality is interpreted subjectively. When working quantitatively, the post-positivist paradigm encourages multiple measurements and observations but accept that all measurements contain a degree of error. Under post-positivism, the researcher is a data collection instrument and not a knower of anything since not everything is completely knowable (Henderson, 2011). Post-positivists reject the belief that any single person can perceive the world perfectly as it is (Panhwar et al., 2017)

4.5 Using Secondary Data for Purposes of the Current Study

Secondary data refers to data that a different person had collected from the user for another primary purpose (Johnston, 2014). Secondary data is used to get an in-depth understanding of the primary data that was collected.

4.5.1 Advantages of using secondary data

Using secondary data has a number of advantages. Using secondary data is efficient and time saving on the part of the researcher. The researcher obtains data ready for analysis since the preliminary work on it, for example, data cleaning, would have been done already (Doolan & Froelicher, 2009; Martins et al., 2018). The data's validity and reliability would often have been established through scrutiny and criticism from peer researchers and other interested parties (Boslaugh, 2007; Doolan & Froelicher, 2009). For the data used in this study, TIMSS went to great lengths to ensure that their data collection methods were valid and reliable (Mullis et al., 2016).

4.5.2 Disadvantages of using secondary data

The use of secondary data also has some disadvantages. The main disadvantage of using secondary data is that it was collected for a different purpose. It may also be a challenge to verify the accuracy and authenticity of the data, especially if the data was collected by entities that are not well known (Boslaugh, 2007; Johnston, 2014). The data might also become obsolete with time as new information becomes available; hence, it is important to know when the data was collected (Johnston, 2014).

For this study, TIMSS Numeracy 2015 data was used since it was the most current TIMSS study results available when this study was conceptualised in January 2019. TIMSS Numeracy 2015 was conducted by the Human Sciences Research Council (HSRC) according to IEA guidelines.

4.6 Data Collection for the Current Study

For this study, overall learner Grade 5 achievement data and some selected items from the parent questionnaire were used. For every learner who completed the TIMSS Numeracy 2015 assessment, their parents were requested to complete the home questionnaire (Early Learning Survey), which mainly looked at home level factors that might affect the learning of mathematics.

4.7 Participants for this Study

The participants for this study were the parents of Grade 5 learners in South Africa who were selected to participate in the TIMSS Numeracy 2015 study[4]. The parents of the participating learners were asked to complete an Early Learning Survey (ELS) questionnaire, which mainly looked at the home level factors that might affect mathematics learning (Hooper et al., 2013).

4.8 Sample Size

Ten thousand nine hundred and thirty-two (10 932) learners wrote the TIMSS assessment and 10 493 parents of Grade 5 learners completed the Early Learning Survey. Parents or guardians of learners sampled in intact classes completed the ELS questionnaire; there was no separate parent/guardian sample. For this reason, any result is interpreted in terms of the parents of learners.

4.9 Data Instruments Used in This Study

The data instruments used in this study included:

- The achievement instruments – booklets completed by learners based on a matrix selection of items from which Plausible Values (PV's) were derived for mathematics scores.

[4] Sampling was done at learner level and not at parent level, therefore the reference is to parents of learners.

- The Parent Questionnaire (Early Learning Survey) – completed by parents or guardians of the learner sample
- The Learner Questionnaire – completed by the learners who participated in the TIMSS Numeracy 2015 study.
- Variables Selected for the Current Study

As described in Chapter 3, the conceptual framework was used to guide the selection of variables for this study. Data from the home questionnaire is available to investigate the relationship between parental attitudes, beliefs, expectations and learner achievement.

Nine predictors were chosen for this study, shown in Table 4.1. Some of the predictor variables, for example, gender of the learner, test language and frequency of speaking the language of the test, were obtained from the learner questionnaire. The IEA also used some items from the learner questionnaire to create the construct called the *number of home study supports* used in this study. The variables which measured the same construct were grouped as shown in Table 4.1.

The variable links to the conceptual framework (see Figure 5.1) are shown to clarify the inclusion of chosen predictors in the model.

Table 4.1 Regression model variables, constructs formed and original response options

Questionnaire	Conceptual Framework	Construct	Variable name	Variable Description	Response options
Home	Parental attitudes, beliefs and expectations (ABE)	Parental expectation	ASBH21	How far in his/her education do you expect your child to go?	1. Finish lower secondary school
					2. Finish upper secondary school
					3. Finish a post-secondary education, non-tertiary education
					4. Finish short-cycle tertiary education
					5. Finish a Bachelor's or equivalent
					6. Finish post-graduate degree; Master's or Doctor
Home	Parental attitudes, beliefs and expectations (ABE)	Homework involvement	ASBH09BA	Ask if your child has done his/her homework	1. Everyday
					2. 3 or 4 times a week
			ASBH09BB	Help your child with homework	3. 1 or 2 times a week
			ASBH09BC	Review your child's homework to make sure it is correct	4. Less than once per week
					5. Never or almost never
Home	Parental attitudes, beliefs and expectations (ABE)	Early literacy and numeracy activities before school	ASBH02A	Read books to your child	1. Never or almost never 2. Sometimes 3. Often
			ASBH02B	Tell stories	
			ASBH02C	Sing songs	
			ASBH02D	Play with alphabet toys	
			ASBH02E	Talk about things you had done	
			ASBH02F	Talk about things you had done	
			ASBH02G	Play games	
			ASBH02H	Write letters or words	
			ASBH02I	Read aloud sounds and labels	
			ASBH02J	Say counting rhymes or sing counting songs	
			ASBH02K	Play with number toys	
			ASBH02L	Count different things	
			ASBH02M	Play games involving shapes	
			ASBH02N	Play with building blocks	
			ASBH02O	Play board or card games	
			ASBH02P	How often do you write numbers	
Home	Parental attitudes, beliefs and expectations (ABE)	Parental attitudes towards mathematics and science	ASBH16A	Most occupations need skills in maths	1. Less than positive attitude 2. Some positive attitude 3. Very positive attitude
			ASBH16B	Science and technology may help solve the world's problems	
			ASBH16C	Science explains how things in the world work	
			ASBH16D	My child needs mathematics to get ahead in the world	
			ASBH16E	Learning Science is for everyone	
Home	Parental attitudes, beliefs and expectations (ABE)	Discussions with child	ASBH02B	How often do you tell stories	1. Never or almost never 2. Sometimes 3. Often
			ASBH02E	how often do you talk about what you had done	
			ASBH02P	How often do you write numbers	
			ASBH02N	How often do you use building blocks	
			ASBH02F	How often do you discuss books	

Questionnaire	Conceptual Framework	Construct	Variable name	Variable Description	Response options
Home	Resources	Private tutoring attendance	ASBH10AA	During the last 12 months, has your child attended extra lessons or tutoring not provided by the school in the following subject: Mathematics?	1. Yes, to excel in class 2. Yes, to keep up in class 3. No
Home	Resources	Private tutoring frequency	ASBH10BA	For how many of the last 12 months has your child attended extra lessons or tutoring in mathematics?	1. Did not attend 2. Less than 4 months 3. 4-8 months 4. More than 8 months
Home	Resources	Home resources for learning	ASBG04	How many books are in the home	1. Few resources 2. Some resources 3. Many resources
			ASDG05S	Number of home study supports	
			ASDHOCCP	Highest level of occupation of either parent	
			ASBH14	Number of children's books in the home	
			ASDHEDUP	Highest level of education of either parent	
Learner	Resources	Number of home study supports	ASDG05S	Do you have an own room and/or internet at home?	1. Neither Own Room nor Internet Connection 2. Either Own Room or Internet Connection 3. Both Own Room and Internet Connection
Home	Background Factors	Gender	ITSEX	Gender of learner	1. Male 2. Female
Learner	Background Factors	Language of Testing	ITLANG	Which language did you use to write the test?	1. English 2. Afrikaans
Home	Background Factors	Frequency of speaking language of testing	ASBH19	How often does the child speak the language of the test at home?	1. Never 2. Sometimes 3. Almost always 4. Always

Adapted from Hu et al. (2021)

4.10 Data Analysis

4.10.1 Data analysis approach

For purposes of this study, descriptive analysis was conducted to describe and summarise each of the variables selected. Following the descriptive discussion, inferential statistics were then conducted as follows:

1. Factor analysis – to check whether the items in the researcher created scale measured one factor;
2. Reliability analysis – to determine whether the items grouped had a high enough inter-item correlation to justify the creation of a scale; and
3. Regression analysis – to assess the strength of the relationship between the predictors and the outcome variable (overall mathematics achievement).

The descriptive and inferential analyses were done using the IEA IDB Analyzer, a specialised software tool developed by the IEA to analyse data for the different large-scale assessments (Howie et al., 2017). The IDB Analyzer uses the Statistics Package for Social Sciences (SPSS) software as a platform.

4.10.2 Descriptive Statistics

According to McMillan (2016, p. 143), descriptive statistics help to convert a set of numbers into indices to describe and summarise data from a sample. Descriptive statistics may include graphs, scatter plots and frequency tables which may help one to "visualise" the data and identify trends. For this study, descriptive statistics were used to summarise parent responses of selected items used. The descriptive statistics helped show the general picture of how parents of Grade 5 learners responded to selected items. The summary of the responses obtained from descriptive statistics may help provide a general overview of parental ABE towards mathematics. Descriptive statistics for this study were generated on the variables selected from TIMSS 2015 by using the SPSS syntax generated by the IDB Analyzer. The descriptive statistics were weighted so that percentages were representative of the population and not the sample. The IDB Analyzer applies population weights so that percentages represent the intended population rather than the sample sizes (Howie et al., 2017). Weights are the inverse of a learners' chance of being included in the sample, with adjustment for non-response (LaRoche et al., 2016). Applying sample weights ensures that the summary statistics represent the population to which the sample was drawn and not exactly from the sample used (Howie et al., 2017).

4.11 Factor Analysis

Factor analysis is a data reduction method used to determine the variables or items that form groupings (Field, 2018). For purposes of this study, Principal Components Analysis (PCA) was utilised to group together the items that measured the same construct. According to Watkins (2018), PCA is a factor analysis method used to identify the latent traits or constructs that may explain the covariation between the observed variables or items. The reduction of variables to just a few factors assist in making it easier to work with the research data. Factor analysis is important in cases where items are designed to form one underlying construct to be combined into one variable that represents the latent trait (Field, 2018; Yong & Pearce, 2013).

For the current study, before the factor analysis could be done, some scales had to be created to enable items to be grouped depending on the construct they measured. Grouping sets of items into scales helps to increase the levels of measurement accuracy of the underlying construct rather than a single item. A factor should be made up of not less than three items (Field, 2018). Scales have the advantage in that they increase the reliability in the measurement of a latent trait that cannot be observed directly (Yong & Pearce, 2013).

4.11.1 Scales created

Once the items were identified from the questionnaires based on the conceptual framework, the next step was to combine or group the items according to the measured factors.

Table 4.2 shows the variable names found in the international database, the response options and the construct that would be used or created for the linear regression modelling.

Table 4.2

Original variables used of interest used in current study

Variable name	Question Description	Response options	Construct as per study framework
ASBH02B	How often do you tell stories	1. Never or almost never 2. Sometimes 3. Often	Discussions with child
ASBH02E	how often do you talk about what you had done		
ASBH02P	How often do you write numbers		
ASBH02N	How often do you use building blocks		
ASBH02F	How often do you discuss books		
ASBH09BA	How often do you ask a child about homework	1. Never or almost never 2. Less than once a week 3. 1 or 2 times a week 4. 3 or 4 times a week 5. Every day	Homework Involvement
ASBH09BB	How often do you help your child with homework		
ASBH09BC	How often do you review your child's homework		
ASBH16A	Most occupations need maths	1. Less than positive attitude 2. Positive attitude 3. More positive attitude	Parental attitude
ASBH16B	Science and technology may help solve world problems		
ASBH16C	Science explains how things in the world work		
ASBH16D	child needs mathematics to get ahead in the world		
ASBH16E	Learning science is for everyone		
ASBH16F	Technology makes life easier		
ASBH16G	mathematics is applicable in real life		
ASBH16H	Engineering is necessary to design things which are safe and useful		
ASBH02A	Read books	1. Never or almost never 2. Sometimes 3. Often	Early literacy and numeracy activities before starting school
ASBH02B	Tell stories		
ASBH02C	Sing songs		
ASBH02D	Play with alphabet toys		
ASBH02E	Talk about things you had done		
ASBH02F	Talk about what you had read		
ASBH02G	Play word games		
ASBH02H	Write letters or words		
ASBH02I	Read aloud signs and labels		
ASBH02J	Say counting rhymes or sing counting songs		
ASBH02K	Play with number toys		

Variable name	Question Description	Response options	Construct as per study framework
ASBH02L	Count different thing		
ASBH02M	Play games involving shapes		
ASBH02N	Play with building blocks or construction toys		
ASBH02O	Play board or card game		
ASBH02P	Write numbers		
ASBG04	How many books in your home (learner reported)	1. Few resources 2. Some resources 3. Many resources	Home resources for learning
ASBH14	Number of books at home (parent reported)		
ASDG05S	Number of home study supports		
ASDHEDUP	Highest level of education of either parent (parent reported)		
ASDH0CCP	Highest level of occupation of either parent (parent reported)		

Adapted from TIMSS & PIRLS Database (2015)

4.11.2 How new scales were created

Scales were created by grouping items that were thought to measure the same underlying construct. The advantage of putting items on a scale is that it leads to improved measurement of the latent trait or underlying construct compared to a single item. Some scales were created by the IEA and others by the researcher for this study as indicated in Table 4.3. Some scales already exist in the publicly available data sets, and some scales were created for the current study. New scales were created by combining response options through item response theory and setting cut-points (Martin et al., 2016; Yin & Fishbein, 2020). Items that required reversing the categories' order were recoded so that the lowest category represented less of the construct and a higher category represented more of the construct. The new scales are shown in Table 4.3.

Table 4.3

Scales that were created from the original variables

Construct	Original response options	New categories created	Source
Parental Attitude scale	Agree a lot Agree a little Disagree a little Disagree a lot	1. Less than positive attitude 2. Positive attitude 3. Very positive attitude	IEA
Home resources for learning ASBG04	0-10 11-25 26-100 101-200 More than 200	1. Few resources 2. Some resources 3. Many resources	IEA

Construct	Original response options	New categories created	Source
Home resources for Learning ASBH14	0-10 11-25 26-50 51-100 More than 100	1. Few resources 2. Some resources 3. Many resources	IEA
Number of home study supports (ASDG05S)	No room and no internet connection Internet connection or own room Both own room and internet connection	Few resources Some resources Many resources	IEA
Highest level of education of either parent (ASDHEDUP)	Finished some primary or lower secondary or did not go to school Finished lower secondary education Finished upper secondary Finished post-secondary education Finished university or higher	Some resources Few resources Many resources	IEA
Parental homework involvement (ASBH09BA, ASBH09BB, ASBH09BC)	1. Everyday 2. 3 or 4 times a week 3. 1 or 2 times a week 4. Less than once a week 5. Never or almost never	1. Never or almost never 2. Less than once a week 3. 1 or 2 times a week 4. 3 or 4 times a week 5. Everyday	Newly formed
Home Discussions(ASBH02, ASBH02E, ASBH02F, ASBH02N, ASBH02P)	1. Often 2. Sometimes 3. Never or almost never	1. Never or almost never 2. Sometimes 3. Often	Newly formed

Table 4.4

Scales created by the researcher and their new categories

Construct	Original response options	New categories created	Source
Parental homework involvement (ASBH09BA, ASBH09BB, ASBH09BC)	1. Everyday 2. 3 or 4 times a week 3. 1 or 2 times a week 4. Less than once a week 5. Never or almost never	1. Never or almost never 2. Less than once a week 3. 1 or 2 times a week 4. 3 or 4 times a week 5. Everyday	Newly formed
Home Discussions(ASBH02, ASBH02E, ASBH02F, ASBH02N, ASBH02P)	1. Often 2. Sometimes 3. Never or almost never	1. Never or almost never 2. Sometimes 3. Often	Newly formed

After the scales were created, as shown in Table 4.3 and 4.4., it was important to check whether items measured the underlying construct. When a scale fails to measure what it is intended to measure, conclusions based on the results obtained may be invalid. Factor analysis was used to check whether loadings justified the creation of a new construct (Field, 2018; Yong & Pearce, 2018). Factor loadings were obtained for each of the items using SPSS. Factor loadings are a measure of how strongly each of the items is associated with each factor. The items with the strongest factor loadings are the ones that indicate potential underlying constructs, while those items which do not load strongly with the factor are a weak measure or indicator of that factor (Field, 2018; Maree, 2016; Yong & Pearce, 2013).

The other criterion that was considered to determine the number of factors to retain in the scale was scree plots. A scree plot is a line graph of eigenvalues plotted against the factor or component number. The line will make a sharp turn or "elbow", and the factors to the left of that "elbow" will be the ones to be retained (Ledesma et al., 2015; Yong & Pearce, 2013).

4.11.3 Reliability Analysis

After completing factor analysis, reliability analysis was done to check whether all the items had strong enough inter-item correlations to justify the construct's creation. Reliability of an instrument gives a picture of the consistency of that instrument in measurement (Maree, 2016; McMillan, 2016). When items are designed to measure a latent trait, there should be consistency between them since they will measure the same construct (McMilan, 2016). The Cronbach's alpha coefficient is used to measure the internal reliability of a set of items or instruments. If there is a strong correlation between items, then it provides evidence of consistency in responses. A small Cronbach's alpha value indicates a weak correlation between the items (McMillan, 2016).

The Cronbach's alpha coefficient has values ranging from zero to one. According to Cohen (1988), the Cronbach's alpha coefficient may be interpreted as:

- 0.90 – very high reliability
- 0.80 - high reliability
- 0.70 – acceptable reliability
- Below 0.50 - unacceptable

Values for Cronbach's alpha coefficient of less than 0.5 are deemed to show very weak reliability and are generally not acceptable (Cohen, 1988). However, according to Taber (2018), a Cronbach's alpha coefficient of at least 0.40 may be acceptable when the sample size is large and where affective constructs are being measured.

4.12 Missing Data

Large scale surveys are associated with missing data, especially in situations where data collection is done through questionnaires (Myers, 2011). Mistakes in data entry and coding may result in some missing data. Missing data may also be a consequence of the reluctance of respondents to answer some questions, for example, the highest level of education one reached or one's occupation (Myers, 2011). The length of the questionnaire might also cause the respondent to feel discouraged or may require too much of their time and result in them not completing the questionnaire. Respondents may fail to respond to questions if they do not understand the question, which is vague. The possible misunderstanding of questions is associated with questionnaires sent to respondents without someone being there to explain the questions (Neuschimdt, 2018).

According to Cheema (2014), there are three types of missing data. Data may be missing completely at random (MCAR), in which case the missing data has no relationship whatsoever with any of the predictor variables. MCAR implies that the probability of being missing is a constant for all the cases. The second type of missing data is called missing at random (MAR), wherein the probability of data being missing is the same within groups in the observed data. The third type of missing data is data missing not at random (MNAR), which represents data missing for reasons unknown to the researcher. In other words, if missing data is not MCAR or MAR, then it is MNAR. Under MNAR, there is a relationship between the value of missing data and the reason for it being missing.

There are three ways that the IDB Analyzer handles missing data when doing data analysis. Missing data may be completely removed from the analysis by either deleting the whole record if there is a single missing value (Listwise deletion) or by only removing some specific missing values from the analysis (Pairwise deletion). Deleting missing values may lead to bias since it is likely to correspond with specific characteristics of participants.

In this study, the listwise deletion option for dealing with missing data was used. In other words, only cases with complete data were utilised to analyse the TIMSS data used for this study. The listwise deletion method has the advantage of being simple to implement and may easily be understood (Newman, 2014). However, the listwise deletion method has a drawback of reducing the effective sample size, which may lead to biased findings since the responses will be those of a fraction of the original sample. Reduced sample size may lead to the loss of statistical power, resulting in a reduced chance of rejecting a false hypothesis (Myers, 2011).

After dealing with missing values, doing factor analysis and reliability analysis, multiple regression analysis was conducted. The multiple regression analysis is the final inferential statistics conducted in this study; the purpose is to establish predictor variables with a statistically significant relationship with mathematics achievement.

4.13 Multiple Regression Analysis

Multiple regression analysis entails using models that enable prediction and description of the interaction between a dependent variable and two or more independent variables (McMillan, 2016). A multiple regression model is designed to assess whether predictor variables have a significant relationship with the dependent variable (Maree, 2016). Multiple regression was used in this study to explore the relative contribution of each of the predictors in the model (see Table 5.10) to the overall mathematics achievement. It was expected that each of the predictors would have some relationship with the learner achievement score. When combined, the indices would explain a significant portion of the overall learner achievement score variation.

The multiple regression equation can represent the relationship between a dependent variable Y and some independent variables:

$Y = (a + b_1X_1 + b_2X_2 + \cdots + b_kX_k) + \epsilon$ (Maree, 2016). In the multiple regression equation:

- Y is the dependent variable
- $X_1, X_2, . . . , X_k$ are the independent/explanatory variables
- a is the x-intercept
- $b_1, b_2, . . . , b_k$ are the correlation coefficients.

- ϵ represents the error terms, which are the deviations of the predicted values of Y from the observed values of Y.

As part of multiple regression, some assumptions had to be checked first. These assumptions are discussed in Chapter 5. Firstly, it will be assumed that there is a linear relationship between the predictors and the outcome variables. The second assumption to be ensured is that the error terms are normally distributed. Thirdly, it will be assumed that there is no or almost no multicollinearity between the predictor variables.

The regression coefficients are unstandardised, and 40 - 50 score points represent a year of schooling, half a standard deviation or a moderate effect size (Ólafsson et al., 2014, Dummy coding was used to deal with the problem associated with categorical indices in regression analysis. This feature is built into the IDB Analyzer. The IDB Analyzer automatically codes categorical variables using dummy codes to convert the categorical variables to dichotomous variables. Dummy coding compares each category of a variable with the reference variable (Alkharusi, 2012). In the current analysis, the lowest category was used as the reference category. The final results show each category in relation to the reference category.

4.14 Use of Plausible Values in Reporting Achievement

Plausible values are imputed values that were empirically generated to approximate a learner's specific proficiency (Foy et al., 2016). As described in Chapter 2, learners who participated in TIMSS Numeracy 2015 did not respond to the full range of the questions in the items pool but only to a subset of the questions. Plausible values are used (Foy et al., 2016) to estimate how a learner would have fared had they answered the whole set of questions in the mathematics assessment. The plausible values method uses all pertinent variables that are learner responses to the items and background information collected. Including background data in the derivation of plausible values help to ensure that a holistic picture of a learner's performance is obtained, which considers the relationship between background information and learner proficiencies (Foy et al., 2016).

Using Item Response Theory (IRT), a model is generated that estimates the likely mathematics score of a learner after factoring the learners' background information and how the learner answered the set of questions administered to him/her. The IRT model statistically generates a probability distribution (posterior distribution) of likely mathematics proficiency for each learner. Plausible values are not an estimate of the individual score of each learner. Instead, five plausible (possible) values were randomly drawn from the statistically generated probability distribution (Foy et al., 2016). All the posterior distributions of learners who participated in the TIMSS Numeracy 2015 assessment were combined to produce a population distribution. This population distribution allows for the calculation of unbiased population statistics such as mean, variance and percentiles. Analysis of the results is done five times using the five plausible values for each learner's achievement in mathematics. The analysis results are combined in the end to generate a "true" mark for an individual learner. This "true" score approximates the score that the learner was most likely to get had they answered all the questions in the item pool. The average of plausible values of learners in the same group was calculated to obtain a group-level estimate of mathematics achievement (Clerkin & Gulligan, 2018; Laukaityte & Wiberg, 2017).

The advantages of using plausible values are that secondary data analysis may be conducted using programs such as SPSS to analyse the data. The plausible values approach also considers the background information about a learner when calculating the likely achievement score for each learner (Laukaityte & Wiberg, 2017). Plausible values allow for the calculation of population parameters instead of individual scores, which is the objective of large-scale assessments to gauge the standard or progress of a group of learners (Foy et al., 2016; Laukaityte & Wiberg, 2017). For the current study, the overall mathematics scores (Plausible Values) for South Africa were used as a measure of mathematics achievement.

4.15 Research Ethics

The Human Sciences Research Council (HSRC) conducted the TIMSS and TIMSS Numeracy 2015 studies on behalf of the Department of Basic Education. The Minister of Basic education granted permission to the HSRC to conduct the study. The Department of Basic education gave the HSRC a list of all the schools in South Africa. The HSRC drew a national sample of schools, learners, teachers, parents, and principals who participated in the study from this list. Each would-be participant was informed through a letter that they had been selected to participate in the TIMSS Numeracy 2015 study. The letter outlined the details of the study, and each would-be participant had the option to decline the invitation to participate. No one was coerced to participate in the study, and each person who participated did so voluntarily. Parents signed consent letters for their children to participate in the study.

Data gathering for the TIMSS Numeracy 2015 study was done through questionnaires. The questionnaire that parents completed was called the Early Learning Survey and was completed by the parents of learners who wrote the mathematics achievement test. No participant was requested to write their names or to disclose their identities. Identity numbers were assigned to each participant, and these identity numbers were kept confidential. The TIMSS data is kept by the HSRC and is available on request from any person since it is public information.

Permission to embark on this study was sought and obtained from the University of Pretoria Research Ethics Committee. A clearance certificate was issued (the ethical clearance certificate is attached). Since this study is a secondary analysis of data, the researcher did not have any physical interaction with the participants; therefore, the participants' privacy was not affected in any way. The conducting of this study did not in any way pose any danger or harm to the participants. The researcher did not know any of the participants; hence the confidentiality of information was never compromised.

4.16 Summary

Chapter 4 covered the research design and methods that were used for the current study. The post-positivist paradigm was the guiding paradigm for the current research. The post-positivist paradigm acknowledges the existence of a single reality that can be discovered by science. However, post-positivists object to the notion that a researcher can be wholly objective since every person is inherently subjective and brings certain biases to research. These biases affect observations and measurements.

This chapter described the process that was followed to create the scales that were used in conjunction with appropriate scales already created by the IEA as part of the international data for purposes of the current study. The selection of the scales was informed by the conceptual framework as described in Chapter 3. The data analysis was done using the IDB Analyzer software developed by the IEA. This chapter first presented the factor analysis and reliability analysis as two data reduction methods used to ensure defensible constructs were created from items. Secondly, multiple linear multiple regression analysis was conducted to investigate the extent of the relationship between parental ABE and learner achievement in mathematics.

Chapter 5
Results

5.1 Introduction

The current chapter contains the results of the secondary data analysis. A multiple linear regression analysis was conducted to investigate the extent of the relationship between parental ABE and learner achievement in mathematics. The chapter discusses linear multiple regression analysis regarding the proportion of the variance for the mathematics score explainable by each of the predictors selected. The multiple regression analysis also shows which variables are statistically significant in the model, i.e. factors with a strong and significant relationship with Grade 5 mathematics achievement.

The findings are divided into three sections, firstly looking at the descriptive statistics in Section 5.2.1. Factor analysis is described in Section 5.2.2. The following section (5.2.3) provides the results for the reliability analysis and the interpretation of Cronbach's alpha values. Lastly, Section 5.2.4 presents results obtained from the multiple regression analysis in establishing the variables that predicted the outcome variable in a statistically significant way.

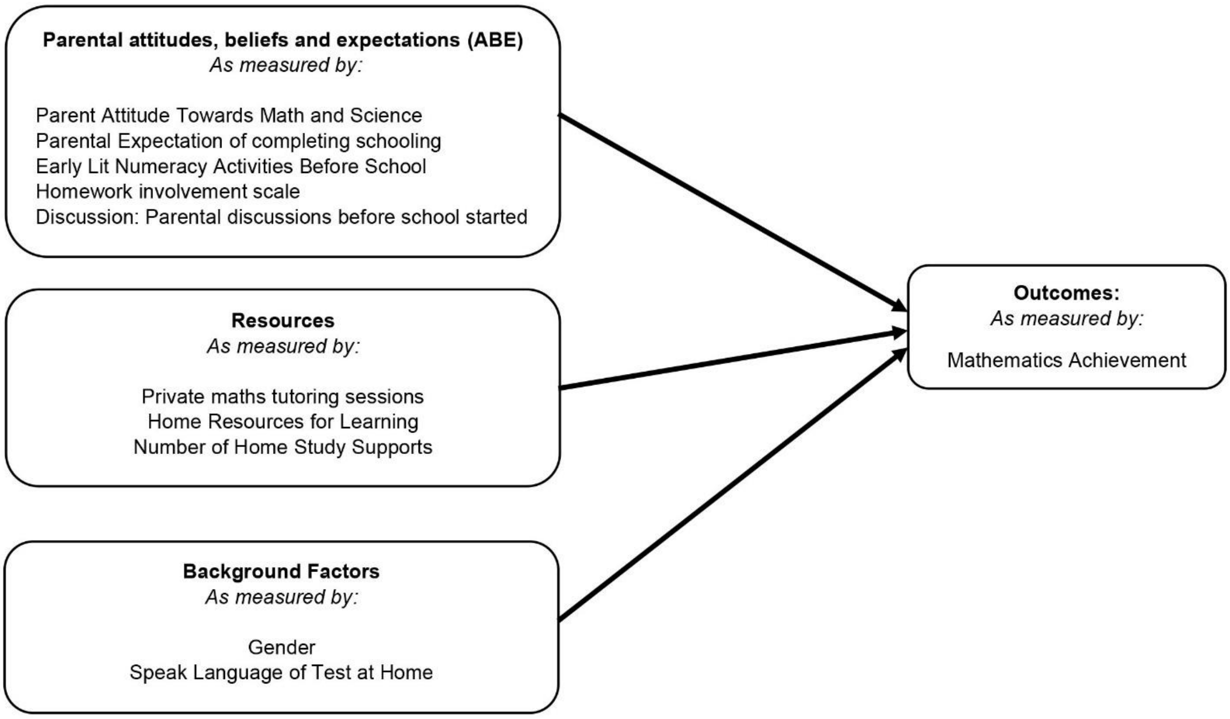
5.2 Findings – Descriptive Statistics

The descriptive statistics relate to the parents' weighted response for each category of a chosen variable. Percentages of parents in each response category are shown.

In Figure 5.1, the conceptual framework is shown again, this time reduced to represent the variables as applied in the current study. Note that the Parental attitudes, beliefs and expectations (ABE) were measured by variables such as parents' attitudes towards maths, their expectation of what their child will achieve after school and their involvement. In the original framework, providing resources such as tutoring were mediating factors, but in the current application these are fixed factors as shown in Figure 5.1. Background variables considered due to the South African context but not in the original conceptual framework are the gender of the child and whether the language of the test is spoken at home, and how frequently.

Figure 5.1

Conceptual Framework as applied in current study



Adapted from Weerasinghe (2016a)

5.2.1 Parental expectations about their children

Parents were asked how far they expected their children to go with their education. Table 5.1 shows the summary of the responses of the parents. The responses ranged from "finishing in lower secondary school" to "finishing a postgraduate degree". The responses showed that the majority of the parents, 54% $(N = 5088;\ SE = 1.32)$, expected their children to finish a postgraduate degree. The high percentage of parents expecting their children to finish a postgraduate degree may be due to the status in society that parents associate with someone with a postgraduate degree.

Table 5.1

Parental expectations about how far their child will go academically

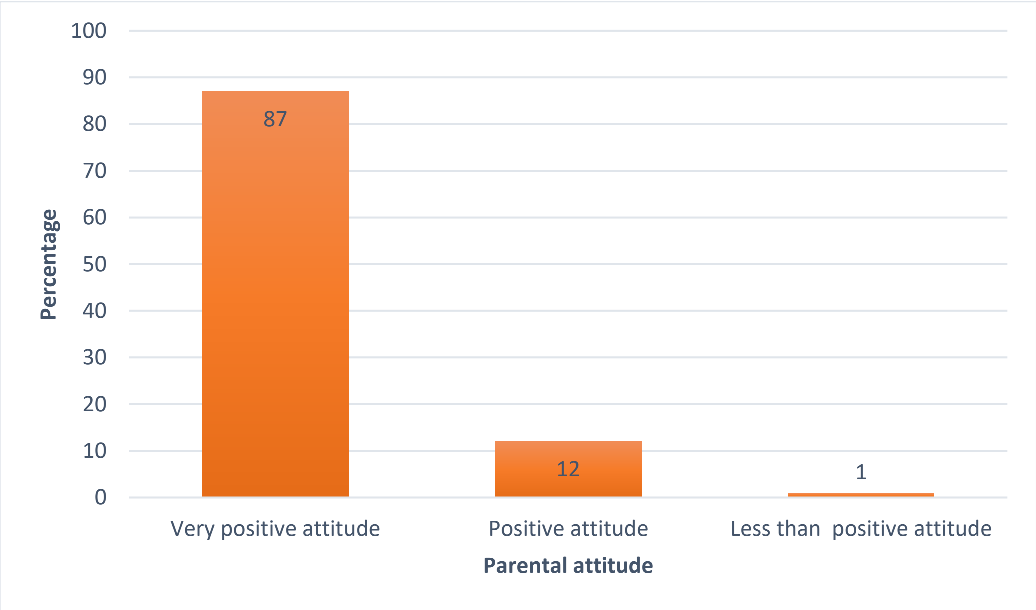
Predictor	Question(s) asked	Category	N	Weighted %	SE
Parental expectation	How far in his/her education do you expect your child to go	Finish Lower secondary	230	2%	0.26
		Finish Upper secondary	1170	11%	0.71
		Finish Post-secondary, non-tertiary	451	4%	0.27
		Finish Short-cycle tertiary	1084	12%	0.76
		Finish Bachelor's or equivalent	1624	17%	0.68
		Finish Postgraduate degree	5088	54%	1.32

5.2.2 Parental attitudes towards mathematics

Parents of Grade 5 learners were asked about the extent to which they agreed that mathematics and science were important subjects applicable in real life. Figure 5.1 summarises the responses of parents to items on parental attitude towards mathematics.

Figure 5.2

Parental attitude towards mathematics and science



Most parents reported a positive attitude towards mathematics, with 87% ($N = 8216$; $SE = 0.78$) saying they are very positive. Only about one in every hundred parents reported a less than positive attitude towards mathematics.

5.2.3 Parental homework involvement

Parents were asked three questions on how often they were involved in their children's homework. The parents' weighted responses are shown in Table 5.2.

Table 5.2

Parental homework involvement

Predictor	Question(s) asked	Category[5]	N	Weighted %	SE
Homework involvement	How often do you ask a child about homework	Every day	6975	72%	1.3
	How often do you help your child with homework	3 or 4 times a week	1216	14%	0.58
	How often do you review your child's homework	1 or 2 times a week	783	9%	0.86
		Less than once a week	225	3%	0.45
		Never or almost never	130	1%	0.31

Most parents reported being involved in their children's homework, with 72% ($N = 6975$; $SE = 1.3$) of parents saying they help their children with homework every day. Only about 1% of the parents were not involved at all in their children's homework. The high percentage of parents reporting being involved in their children's homework may be due to social desirability.

5.2.4 Early literacy and numeracy activities before school

Parents were asked some questions concerning the different literacy and numeracy activities they had done with their children before the child started school. Table 5.3 depicts the descriptive statistics of the Early Literacy Numeracy Activities Before School index, as well as the individual items from which the index was derived.

[5] The category is for the parental homework involvement scale and not for each of the questions making up the scale.

Table 5.3

Early literacy and numeracy activities

Predictor	Question(s) asked	Category[6]	N	Weighted %	SE
Early Literacy Numeracy Activities Before School	Before your child began primary school how, how often did you or someone else in your home do the following activities with the child:	Often	2719	27	1.05
	1 Tell stories 2 Talk about what you had done 3 Write numbers. 4 Use building blocks 5 Discuss books	Sometimes	6308	66	1.08
	6 Sing a song 7 Play word games 8 Write letters or words 9 Read aloud sounds and labels 10 Count different things 11 Play with toys 12 Play with alphabet toys 13 Play with building blocks or construction toys 14 Play board or card games	Never or almost never	579	7	0.86

Close to three in every ten parents reported having done some literacy and numeracy activities with their children before they began school. The majority of the parents, 66% $(N = 6308, SE = 1.08)$ reported participating in the activities with their children only sometimes.

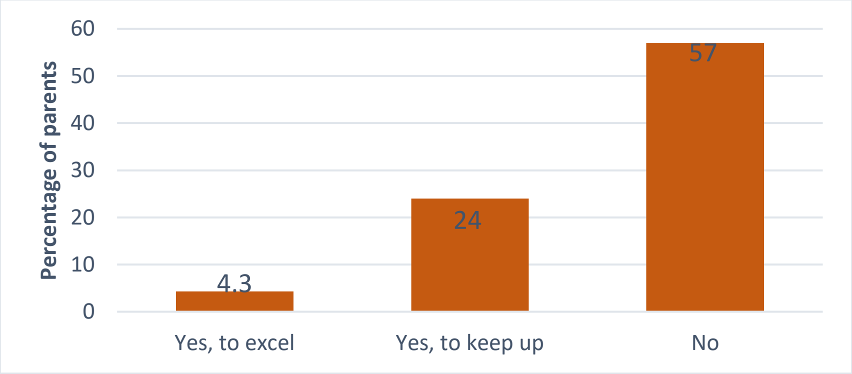
5.2.5 Private tutors in mathematics

Parents of the Grade 5 learners were asked if their children had attended mathematics lessons offered by a private tutor. Figure 5.2 shows the responses. More than half of the parents, 57% $(N = 5552;\ SE = 1.69)$, reported that their child does not go to a private tutor for mathematics lessons. Lack of financial resources might be why many parents were not sending their children to private tutors.

[6] The category applies to the "Early literacy and numeracy activities before school'" scale and not to a single item.

Figure 5.3

Learner attendance at private tutors as reported by parents

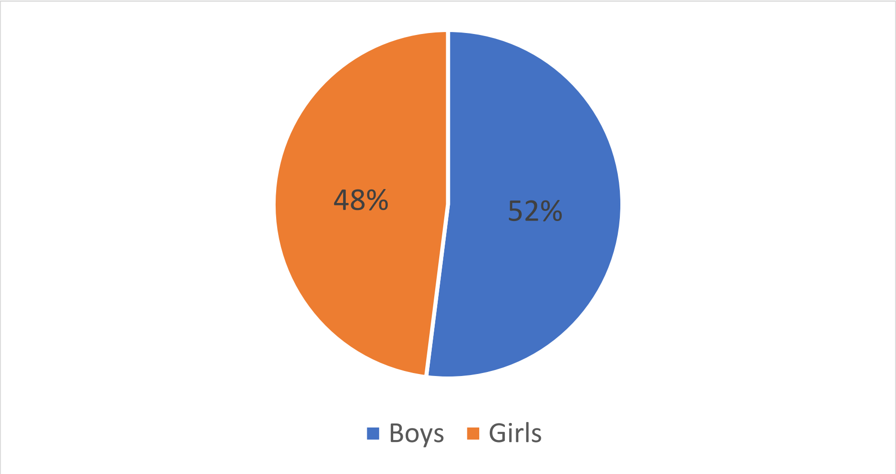


5.2.6 Gender of learners

Figure 5.3 represents the gender distribution of the learners who participated in TIMSS Numeracy 2015.

Figure 5.4

Gender of learners



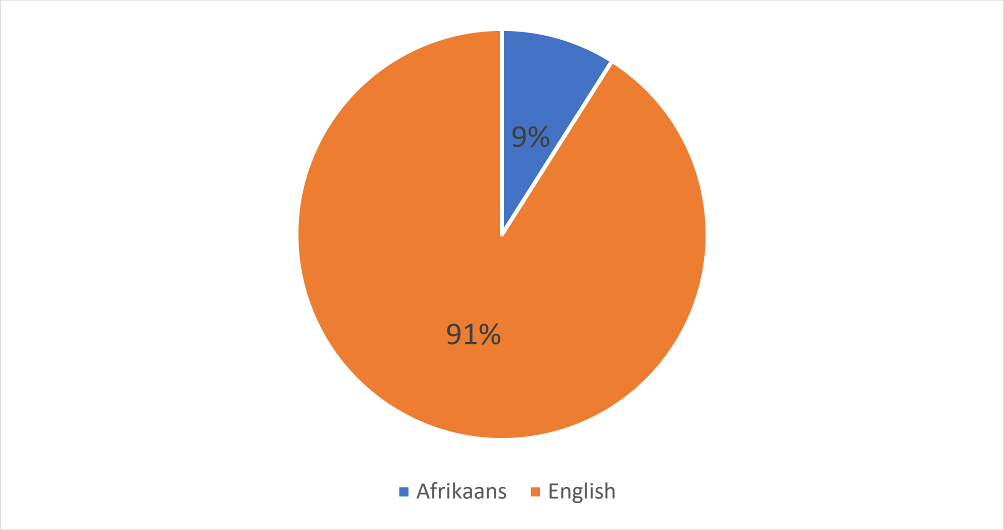
There were marginally more boys than girls who participated in the TIMSS Numeracy 2015 study, with 52% $(N = 5\,601)$ being boys and 48% $(N = 5\,331)$ being girls.

5.2.7 Language of Testing

Learners wrote the TIMSS Numeracy 2015 assessment either in Afrikaans or in English. Figure 5.4 depicts the percentage of learners using either Afrikaans or English as the language of testing.

Figure 5.5

Language in which learners wrote the assessment



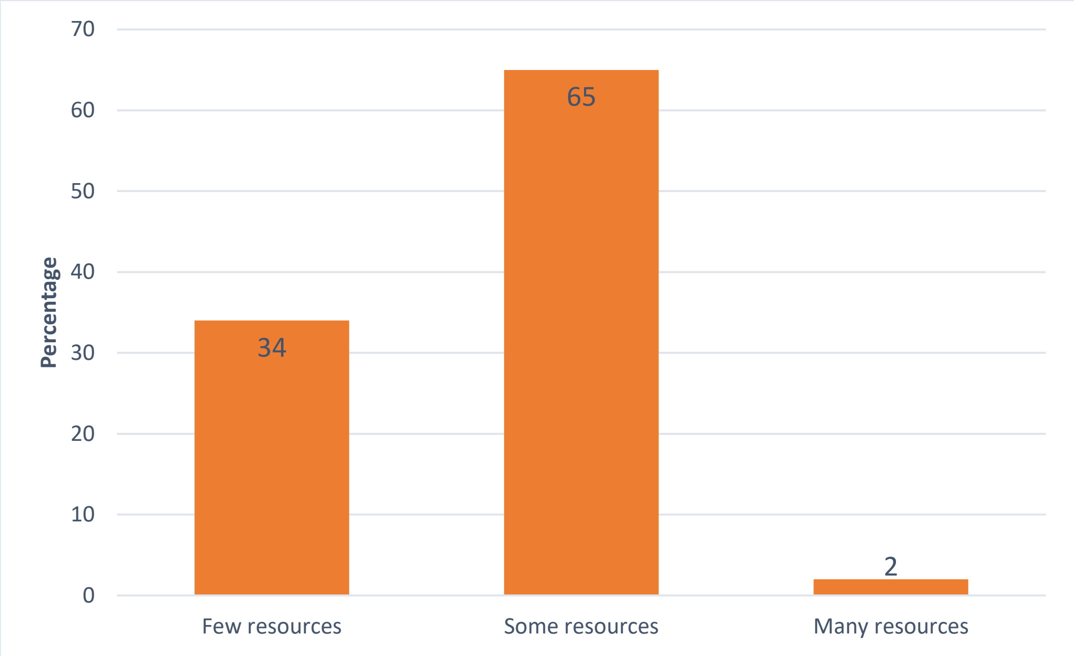
The majority of the South African Grade 5 learners, 91% $(N = 9752, SE = 1.56)$, wrote the test in English. Only 9% $(N = 1180, SE = 1.56)$ wrote the test in Afrikaans. Since learners had no option of writing the assessment in an African language, it might imply that many learners wrote the test in a language that was not their home language, but this is expected as African home language as the medium of instruction ceases after Grade 3. However, it should be noted that some code-switching may be present in later grades.

5.2.8 Home resources for learning

The IEA used questions in the learner and parent questionnaires about the number of books at home, whether a child had their own room and an internet connection, and parents' highest level of education and occupation to create the number of home resources index. Figure 5.5 depicts the percentage of households having few resources, some resources and many resources.

Figure 5.6

Home resources for learning



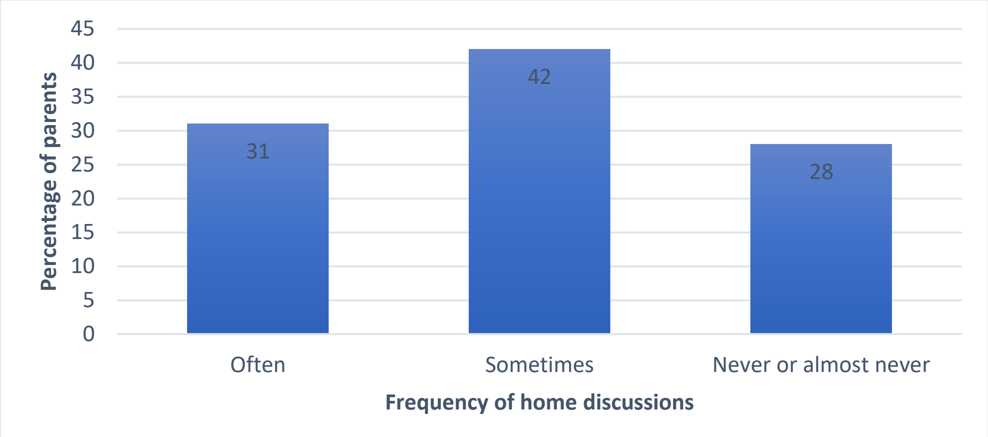
From the information presented in Figure 5.5, more than a third of South African Grade 5 learners came from households with few resources. Only 2% ($SE = 0.35$) of learners hailed from homes with many resources. Internationally, about 9% ($SE = 0.1$) of learners came from families with few resources, while 17% ($SE = 0.2$) of the learners came from families with many resources (Reddy et al., 2016). South Africa, therefore, has a comparatively high proportion of learners coming from poor backgrounds.

5.2.9 Parental home discussions with children

These discussions included parents telling stories to their children, parents reading books to their children and parents asking their children about what they had done during the day. Figure 5.6 represents the responses of the parents. The parents reported having some discussions with their children before they went to school. A total of 31% ($N = 2847$; $SE = 1.06$) of the parents said they often had discussions with their children. Close to a third of the parents (28%) reported having no discussions with their children ($N = 2452$; $SE = 1.15$). The percentage of parents who had home discussions with their children is closely linked to the percentage of parents involved in early literacy and numeracy activities before the child goes to school, as shown in Table 5.3.

Figure 5.7

Home discussions between parents and children



However, the percentage of parents who reported as never or almost never being involved in early numeracy and literacy activities (7%) is significantly lower than parents not involved in home discussions with their children (28%).

5.2.10 Missing data

When data is collected through questionnaires, there is always a chance that some questions will not have been answered or the questionnaire may not be returned altogether. It is important to know the percentage of parents who did not answer the questions (missing values) since the missing values might have a bearing on the sample size of questions that were responded to and, consequently, the reliability and validity of the results (Cheema, 2014).

Table 5.4 shows descriptive statistics for the predictor variables regarding the percentage of missing data for each of the variables. The number of parents who answered is represented by N. Missing data is a common problem, especially in self-reported questionnaires (Cheema, 2014; Demetriou et al., 2014). High percentages of missing data may weaken the statistical power of a study. All the predictors derived from the parental/home questionnaire (for example, the early numeracy activity before school index) had high percentages of missing data. The variable on parental expectations had 11.8% missing data, while the scale on parental attitudes towards mathematics and science had an average of 13.7% missing data. Other scales with high levels of missing data were early literacy and numeracy before school, 12.1%, parental discussions before school started (11.6%), and the variable on frequency of private mathematics lessons (11.6%).

Table 5.4

Descriptive statistics for missing data

Predictor Code	Description	N	Minimum number of categories	Maximum number of categories	Missing %
ASBH21	Parental expectation of completing school	9647	1	6	11.8
ASDHAMS	Parent Attitude Towards Math and Science	9434	1	3	13.7
ASDHELN	Early Literacy and Numeracy Activities Before School	9606	1	3	12.1
Homework Scale	Homework scale	9787	1	2	10.5
ASBH10AA	Extra private maths lessons	9903	1	3	9.4
ASBH10BA	Frequency of maths private lessons	9663	1	4	11.6
ITSEX	Sex of Students	10932	1	2	0.0
ASDGHRL	Home Resources for Learning	9239	1	3	15.5
ASDG05S	Number of Home Study Supports	10252	0	2	6.2
Discussions Home	Parental discussions before school started	9662	1	3	11.6
ASBH19	Speak language of test at home	9839	1	4	10.0
ITLANG	Language of Test	10932	1	2	0.0
Total	Valid N (listwise)	6949			

The home resources for the learning scale had the highest percentage of missing data, 15.5%. The high percentage of missing data on home resource variables may be due to parents' reluctance to divulge information about their economic status. Parents may be unwilling to disclose information about how they feel and how many resources they have. The model's sample size was reduced to 6 949 from 10 932, which is a limitation of the current study. The reduced sample may result in a loss of statistical power for the analysis. However, even though the sample size was reduced by about 30%, it was still representative of the target population since the missing data was missing at random (Cheema, 2014). A sample size of more than 1000 is large enough to retain acceptable statistical power (Cheema, 2014). Other methods of handling missing data, such as multiple imputations, could not be used in this study because the TIMSS IDB Analyzer software program does not handle multiple imputations of missing data.

5.2.11 Learner achievement in TIMSS Numeracy 2015

The South African achievement for TIMSS Numeracy 2015 is summarised in Table 5.5 below. The scores were put on a scale of 0-1000. The international centre point was fixed at 500 with a standard deviation of 100. Learners who obtain 400 and more are deemed to have achieved at least the minimum levels of competence in mathematics. Those learners who obtained a score below 400 are considered not having achieved and lacking the minimum competence in mathematics (Reddy et al., 2016).

Table 5.5

Country performance compared to centre point.

Countries achieving above centre point			*Countries achieving below centre point*		
Country	**Average score**	**SE**	**Country**	**Average score**	**SE**
Singapore	618	3.8	Slovak Republic	498	2.5
Hong Kong	614	2.9	New Zealand	491	2.3
Korea	608	2.2	France	488	2.9
Chinese Taipei	596	1.8	Turkey	483	3.1
Japan	593	1.9	Georgia	463	3.6
Northern Island	570	2.9	Chile	459	2.4
Russia Federation	564	3.4	United Arab Emirates	452	2.4
Norway	549	2.5	Bahrain	451	1.6
Ireland	548	2.2	Qatar	439	3.4
England	546	2.9	Iran, Islamic Rep. of	432	3.2
Belgium (Flemish)	546	2.1	Oman	426	2.5
Portugal	541	2.2	Indonesia	398	3.7
United States	539	2.3	Jordan	389	3
Denmark	539	2.7	Saudi Arabia	384	4
Finland	535	2	Morocco	378	3
Lithuania	535	2.5	South Africa (5)	376	3.4
Poland	535	2.1	Kuwait	354	4.6
Netherlands	530	1.7			
Hungary	529	3.2			
Czech Republic	528	2.2			
Bulgaria	524	5.2			
Cyprus	523	2.7			
Germany	522	2			
Slovenia	520	1.9			
Sweden	519	2.8			
Serbia	518	3.5			
Australia	517	3.1			
Canada	511	2.2			
Italy	507	2.6			
Spain	505	2.5			
Croatia	502	1.7			

Source: Mullis et al. (2016), Reddy et al. (2016)

South Africa was one of the lowest-ranked countries in achievement compared to the other countries that participated, with an average score below the international centre point. The average score for South Africa was 376 ($SE = 3.4$), which was low when compared to the top achieving nation, Singapore, with an average score of 618 points ($SE = 3.8$). With every

40 points representing almost a year of schooling, it implies that South African learners are about six grades behind learners in Singapore (Reddy et al., 2016).

TIMSS uses five international categories or benchmarks to scale learners' scores. These benchmarks are: Advanced International benchmark (greater than 625), High International Benchmark (from 550 to 625), Intermediate International benchmark (475 to 550), Low international benchmark (from 400 to 475) and Not achieved (below 400). However, in the South African context, another benchmark called Potentials (from 325 to 400) was added to signify those learners who had the potential to achieve more and reach higher benchmarks. Table 5.6 summarises the South African Grade 5 learners' achievement per international benchmark.

Table 5.6

Summary of South African learners' achievement

International benchmark	Percentage of learners[7]
Advanced (> 625)	1%
High (550 - 625)	4%
Intermediate (475 - 550)	12%
Low (400 - 475)	22%
Potentials (325 - 400)	28%
Not Achieved (< 325)	33%

Table 5.7 shows that only 1 in 100 South African learners had scores that were higher than 625. More than two thirds (61%) of South African learners did not achieve the lowest benchmark. The 61% who did not reach the lowest benchmark is the sum of the not achieved and the potentials from Table 5.7. However, 28% of the learners were identified as having the potential to perform better and who, if targeted for more support, could move up to higher benchmarks (Isdale et al., 2017; Reddy et al., 2016).

5.2.12 Achievement of South African learners by school type

Learners either went to public schools which are government-owned or to independent schools which are not owned by the government. Public schools are either fee-paying or non-fee-paying. The non-fee-paying public schools are Quintile 1-3, while the Quintile 4-5

[7] Percentages are not cumulative, meaning that learners who reached the advanced benchmark automatically reached the low, intermediate and high benchmarks. Instead, in Table 5.5, discrete benchmarks are provided. Learners in one benchmark belong to that benchmark only and are not included in the lower benchmarks.

are fee-paying public schools. The quintile system was discussed in Chapter 3. Table 5.7 shows the achievement of learners by school type.

Table 5.7

Achievement of learners by type of school

School type	Average score	SE
Public (no fees)	344	3.4
Public (fee-paying)	445	7.7
Independent	506	11.9

From table 5.7, it is discernible that learners going to non-fee-paying public schools had the lowest average of 344 ($SE = 3.4$). Those learners attending fee-paying schools obtained an average of 445 ($SE = 7.7$), while learners attending independent schools had the highest average of 506 ($SE = 11.9$). The observed difference in learners' achievement in the different schools may be linked to the SES of the learners. Learners attending no fees schools are typically from poor backgrounds, while learners attending fee paying government schools are generally from middle-income families and learners from high SES backgrounds. About 70% of learners who participated in TIMSS Numeracy 2015 in South Africa attended no-fee schools, about 27% attended fee-paying public schools, and only about 4% attended independent schools (Reddy et al., 2016). Independent schools mainly cater to learners from high SES backgrounds who can pay the fees charged by the independent schools.

From the achievement of learners in the different school types in South Africa, it can be observed that learners in no-fee public schools, who are the majority, are more likely to perform lower in mathematics than learners from wealthier backgrounds who attend fee-paying public schools and independent schools.

5.3 Findings – Inferential Statistics

5.3.1 Factor/Reliability analysis and scale creation

After the descriptive statistics were done, inferential statistics were calculated, starting with factor analysis. The rationale behind doing a factor analysis, as described in Section 4.11, is to ensure that there is alignment between the selected variables and the latent construct they intend to measure. Factor analysis lets the researcher know which items are strongly associated with the underlying trait, which is used to create the scale. Varimax rotation was used. Theoretically, the items were designed to form a strong, underlying latent trait. The varimax method maximises the number of variables loading onto a factor, leading to more interpretable and defendable factors (Field, 2018). The structure matrix is interpreted due to the focus on the correlation coefficients between items and factors. Loadings were expected to be above 0.30 for exploratory purposes (Field, 2018). The factor loadings for each of the variables were calculated, and the results are shown in Table 5.8.

Table 5.8

Factor loadings and reliability coefficients for the created scales

Factor[8]	Variable name	Question Description	Factor loading	Reliability	Percentage of variance explained	Pearson correlation coefficient with achievement
Early literacy and numeracy activities	ASBH02A	How often do you read books to your child	0.61	0.89	36%	0.23
	ASBH02B	How often do you tell stories	0.50			
	ASBH02C	how often do you sing songs	0.44			
	ASBH02D	How often do you play with alphabet toys	0.63			
	ASBH02E	How often do you talk about things you had done	0.52			
	ASBH02F	How often do you talk about things you had done	0.61			
	ASBH02G	How often do you play games	0.63			
	ASBH02H	How often do you write letters or words	0.64			
	ASBH02I	How often do you read aloud sounds and labels	0.65			
	ASBH02J	How often do you counting rhymes or sing counting songs	0.6			
	ASBH02K	How often do you play with number toys	0.68			
	ASBH02L	How often do you count different things	0.61			
	ASBH02M	How often do you play games involving shapes	0.67			

[8] Factors were derived from conceptual framework as discussed in Chapter 2

Factor[8]	Variable name	Question Description	Factor loading	Reliability	Percentage of variance explained	Pearson correlation coefficient with achievement
	ASBH02N	How often do you play with building blocks	0.6			
	ASBH02O	How often do you play board or card games	0.56			
	ASBH02P	How often do you write numbers	0.6			
Home Resources for learning	ASBG04	How many books are in the home	0.57	0.62	39%	0.41
	ASDG05S	Number of home study supports	0.55			
	ASDHOCCP	Highest level of occupation of either parent	0.58			
	ASBH14	Number of children's books in the home	0.69			
	ASDHEDUP	Highest level of education of either parent	0.7			
Parental attitudes towards mathematics and science	ASBH16A	Most occupations need skills in maths	0.64	0.83	46%	0.04
	ASBH16B	Science and technology may help solve the world's problems	0.72			
	ASBH16C	Science explains how things in the world work	0.7			
	ASBH16D	My child needs mathematics to get ahead in the world	0.7			
	ASBH16E	Learning Science is for everyone	0.6			
	ASBH16F	Technology makes life easer	0.69			
	ASBH16G	Mathematics is applicable to real life	0.71			
	ASBH16H	Engineering is necessary to design things which are safe and useful	0.69			
Discussions with child	ASBH02B	How often do you tell stories	0.623	0.649		
	ASBH02E	how often do you talk about	0.667			

Factor[8]	Variable name	Question Description	Factor loading	Reliability	Percentage of variance explained	Pearson correlation coefficient with achievement
		what you had done				
	ASBH02P	How often do you write numbers	0.618		42%	0.158
	ASBH02N	How often do you use building blocks	0.587			
	ASBH02F	How often do you discuss books	0.738			
Homework Involvement	ASBH09BA	How often do you ask a child about homework	0.725	0.741	66%	0.074
	ASBH09BB	How often do you help your child with homework	0.853			
	ASBH09BC	How often do you review your child's homework	0.854			

As presented in Table 5.9, the items loaded well for each of the factors and the sampling framework was adequate. Having variables which loaded well to the factor implies that there is a strong relationship between the variables and the specified construct. For the factor Discussions with child, the variable ASBH02F showed the strongest relationship since it had the highest factor loading compared to the other variables under the same construct. Items constituting the Early literacy and numeracy activities before school loaded highly to the factor with an exception of ASBH02C with a low factor loading of 0.44. The items making up the Home resources for learning and the Parental attitude towards mathematics also loaded highly onto the respective factors.

According to Yong and Pearce (2013), the objective in performing factor analysis is to model interrelationships between items forming a factor and the percentage of variance explained indicates the overall amount of variance that is accounted for by the items making up the factor. The percentage of variance explained by the items forming each factor are shown in table 5.9. The items making up the early literacy and numeracy scale explain 36% of the variance in the factor, home resources for learning items explain 39% of the factor variability and the items making up the parental attitude towards mathematics and science scale explain 46% of the total variance in the factor. The factor which had the items explained the highest percentage was the homework involvement factor with 66% of total variance explained.

A summary of the Cronbach's alpha for the selected items used by for this study is shown in table 5.9. As can be observed from table 5.9, the reliability was strong for the items measuring early literacy and numeracy activities and parental attitudes towards mathematics, with the reliability coefficients of 0.89 and 0.83 respectively. The items measuring discussions with child construct had a reliability coefficient of 0.649 which is an acceptable level of reliability but less than ideal. Table 5.9 also shows the percentage of the model's variance that is explained by the factor as well as the correlation coefficient between the factor and mathematics achievement.

5.3.2 Scree Plots

As explained in chapter 4, scree test is a graphical method which maybe be used to determine the items or components to be retained in factor analysis (Ledesma et al., 2015). All components with eigenvalues lower than the elbow point are deemed not to be strong enough and may be excluded from the factor. The scree test involves plotting the eigenvalues (y-axis) and the components (x-axis).

Figure 5.10 and Figure 5.11 show the scree plots for newly created scales, that is, parental homework involvement and the home discussions factors respectively. For this study, the items strongly formed one factor and had one eigen-value above 2 as shown in the figures.

Figure 5.8

Scree plot for parental homework involvement

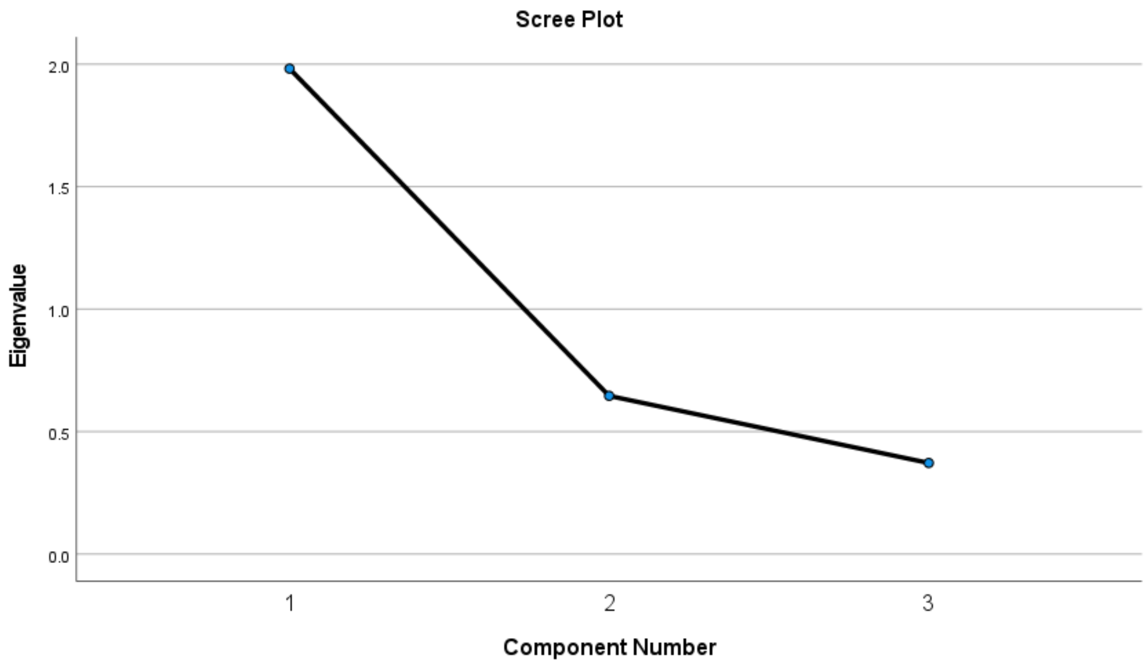
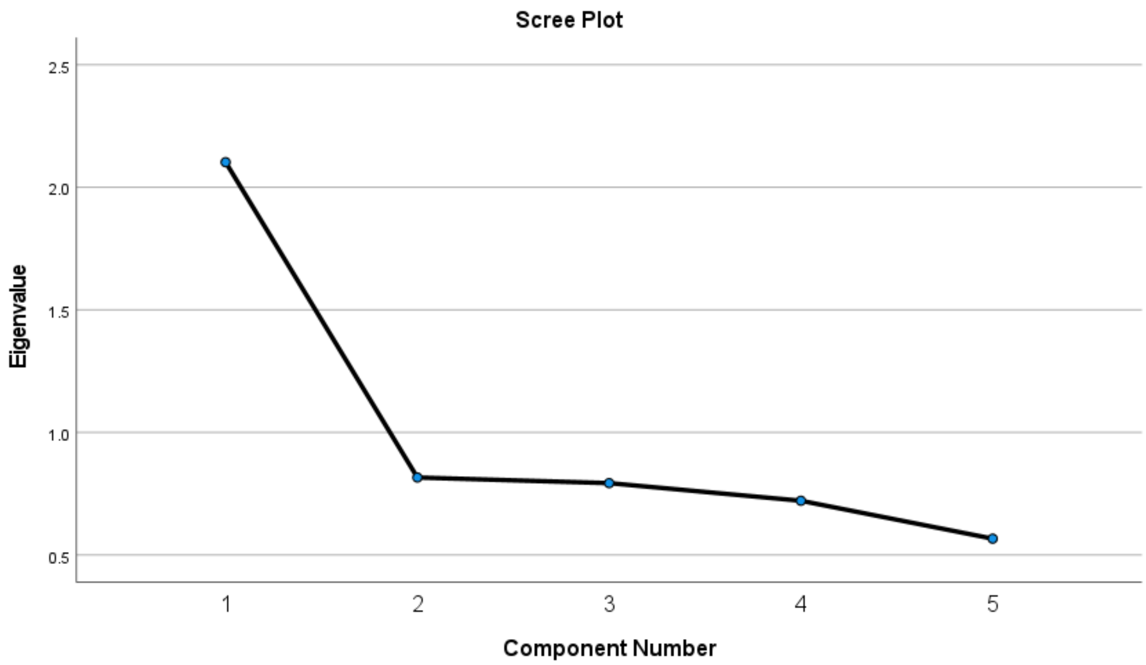


Figure 5.9

Scree plot for home discussions



For inclusion in the multiple linear regression analysis, Table 5.9 shows the final predictors which were used in the model and the categories of each predictor.

Table 5.9

Final predictors used in multiple linear regression analysis

Questionnaire	Variable Name	Predictor (construct)	Category (scale)
Home	ASBH21	Parental expectation of completing education	Finish Lower secondary Finish Upper secondary Finish Post-secondary, non-tertiary Finish Short-cycle tertiary Finish Bachelor's or equivalent Finish Postgraduate degree
Home	ASDHAMS	Parent Attitude Towards Math and Science	Less than Positive Attitude Positive Attitude Very Positive Attitude
Home	ASDHELN	Early Lit Numeracy Activities Before School	Never or almost never Sometimes Often
Home	Homework Scale	Homework scale	Less involved More involved
Home	ASBH10AA	Extra private maths lessons in last 12 months	No Yes, to keep up in class Yes, to excel in class
Home	ASBH10BA	Frequency of maths private lessons in last 12 months	Did not attend Less than 4 months 4-8 months More than 8 months
Learner	ITSEX	Gender of Learners	Female Male
Home	ASDGHRL	Home Resources for Learning	Few Resources Some Resources Many Resources
Learner	ASDG05S	Number of Home Study Supports	Neither Own Room nor Internet Connection Either Own Room or Internet Connection Both Own Room and Internet Connection

Questionnaire	Variable Name	Predictor (construct)	Category (scale)
Home	Home discussions	Parental discussions before school started	Less discussion Moderate discussions Many discussions
Learner	ITLANG	Language of Testing	English Afrikaans
Home	ASBH19	How often does the child speak the language of the test at home?	Never Sometimes Almost always Always

The lowest category for each predictor was utilised as the reference category and the predictors were coded from least to most.

5.3.3 Multiple linear regression analysis results

The assumptions of linear multiple regression analysis were assessed before the model was run to assure appropriate use of all predictors (Field, 2018). Commonly accepted assumptions of linear multiple regression include a lack of perfect multicollinearity, linear relationships between predictors and outcome variables, as well as independent errors. The independent errors represent the margin of error in using a linear multiple regression, that is, the variability in the dependent variable that the predictor variables may not explain in the model (Williams et al., 2012).

Assumption 1: Linear relationship between predictors and outcome variables

The assumption that the predictor variables have a linear relationship with the outcome variable was assessed with the correlations shown in Table 5.9. Some of the predictors had no discernible relationship with the outcome variables, such as the parental attitude scale (0.067), the homework scale (0.071), private lessons (-0.087) and gender (-0.092). These predictors without any statistically significant relationship with learner achievement may weaken the model, but they were retained as the analysis is theory rather than data-driven.

Table 5.10

Correlations between predictors and outcome variable

Predictor	Statistics	1ST TO 5TH PLAUSIBLE VALUE MATHEMATICS
Parental expectation of completing	Correlation Coefficient	0.173**
	Sig. (2-tailed)	0,000
	N	9647
Parent Attitude Towards Math and Science	Correlation Coefficient	0.067**
	Sig. (2-tailed)	0,000
	N	9434
Early Lit Numeracy Activities Before School	Correlation Coefficient	0.200**
	Sig. (2-tailed)	0,000
	N	9606
Homework scale	Correlation Coefficient	0.071**
	Sig. (2-tailed)	0.000
	N	9787
Extra private maths lessons in last 12 months	Correlation Coefficient	-0.087**
	Sig. (2-tailed)	0,000
	N	9903
Frequency of maths private lessons in last 12 months	Correlation Coefficient	-0.068**
	Sig. (2-tailed)	0,000
	N	9663
Gender	Correlation Coefficient	-0.092**
	Sig. (2-tailed)	0,000
	N	10932
Home Resources for Learning	Correlation Coefficient	0.237**
	Sig. (2-tailed)	0.000
	N	9239
Number of Home Study Supports	Correlation Coefficient	0.146**
	Sig. (2-tailed)	0.000
	N	10252
Parental discussions before school started	Correlation Coefficient	0.150**
	Sig. (2-tailed)	0.000
	N	9662

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Assumption 2: Independent errors

The residuals terms of the predictors should be normally distributed with independent errors. A residual for an observed value is the difference between the predicted value of the dependent variable and the observed value. If the errors are independent, the value of an error term for a particular set of predictor variables will not be related to another error term for any other set of values of independent variables (Williams et al., 2012). The Durbin–Watson test showed a value of 1.214, well within the range of 1 to 3, which is a conservative estimation. The assumption on independent errors held for the analysis.

Assumption 3: No or almost no multicollinearity

This step assumes that the independent variables are not highly correlated with each other. If the correlation between the predictor variables is high, it may cause problems when one tries to fit the model and interpret results (Williams et al., 2012). Predictor variables should not be overly correlated with one another (Williams et al., 2012). Multicollinearity may reduce the predictive power of the independent variables, which in turn will lessen the statistical power of the linear multiple regression model. This assumption is tested using a correlation matrix to assess each predictor’s relationship with every other predictor as shown in Table 5.11.

Table 5.11

Correlation matrix to assess multicollinearity

	Parental expectation of completing	Parent Attitude Towards Math and Science	Early Literacy and Numeracy Activities Before School	Homework scale	Extra private maths lessons in last 12 months	Frequency of maths private	Sex of Students	Home Resources for Learning	Number of Home Study Supports	Parental discussions before school started
Parental expectation of completing		.196**	.046**	.057**	-.140**	-.081**	-.045**	.103**	.053**	.037**
Parent Attitude Towards Math and Science	.196**		.093**	.108**	-.112**	-.093**	-0.011	-0.008	0.014	.098**
Early Literacy and Numeracy Activities Before School	.046**	.093**		.182**	.042**	-0.002	-.055**	.165**	.112**	.661**
Homework scale	.057**	.108**	.182**		.125**	.072**	-.046**	.055**	.029**	.169**
Extra private maths lessons	-.140**	-.112**	.042**	.125**		.613**	-.022*	0.001	-.040**	.033**
Frequency of maths private lessons	-.081**	-.093**	-0.002	.072**	.613**		-.024*	0.005	-.037**	-0.003
Sex of Students	-.045**	-0.011	-.055**	-.046**	-.022*	-.024*		0.018	.113**	-.033**
Home Resources for Learning	.103**	-0.008	.165**	.055**	0.001	0.005	0.018		.425**	.144**
Number of Home Study Supports	.053**	0.014	.112**	.029**	-.040**	-.037**	.113**	.425**		.100**
Parental discussions before school started	.037**	.098**	.661**	.169**	.033**	-0.003	-.033**	.144**	.100**	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5.11 shows that none of the predictors was overly correlated; the highest correlation was $r = 0.425$. Multicollinearity is considered a problem if the absolute value of the correlation is greater than 0.7 (Williams et al., 2012). Multicollinearity was judged to not be problematic or a threat to the model.

After establishing that the variables met the assumptions for multiple linear regression analysis, the researcher proceeded with the analysis. The findings are first presented in terms of model functioning; after that the coefficients per predictor. The percentage of variance explained by the model is shown in Table 5.12.

Table 5.12

Model variance explained

R-Squared	Adjusted R-Squared	Standard Error
0.32	0.32	0.03

The amount of the variance explained by the model is 32% $(SE = 0.03)$. This value means that the predictor variables in the model may explain approximately a third of the variance in the mathematics score. The adjusted R-squared represents the value R-squared after adjusting for the number of predictor variables to avoid overestimating the effect of adding another independent variable on the variability explained by the regression equation (Williams et al., 2012).

After obtaining the variance explained by the model, the data analysis was run using the IDB Analyzer, and the linear multiple regression coefficients obtained are as presented in Table 5.13. Having parents with high expectations (as measured by the expectation for their child to finish a bachelor's degree or equivalent) could improve their child's score in mathematics by 30 score points ($SE = 14.28$). This value was statistically significant at the 0.05 level ($t > 1.96$) if all other factors were held constant. Additionally, having parents who expected their children to finish a post-graduate degree may improve their mathematics score by a statistically significant 38 score points ($SE = 13.82$), which is approximately a year of schooling. Parents who expect their children to obtain a tertiary degree could lead to significantly higher numeracy achievement for Grade 5 learners. However, some categories, like parents expecting their child to finish upper secondary school, finish secondary, non-tertiary education and finish short-cycle tertiary education, were not statistically significant.

Table 5.13

Multiple linear regression coefficients

Predictor	Category	*b*	*b.se*	*t-value*
(CONSTANT)		251.04	25.50	9.85**
ASBH21 Parental expectation of completing schooling	Finish Upper secondary	5.29	14.75	0.36
	Finish Post-secondary, non-tertiary	6.71	14.52	0.46
	Finish Short-cycle tertiary	13.26	16.70	0.79
	Finish Bachelor's or equivalent	30.76	14.28	2.15*
	Finish Postgraduate degree	38.32	13.82	2.77**
ASDHAMS Parent Attitude Towards Math and Science	Positive Attitude	31.92	21.39	1.49
	Very Positive Attitude	23.67	21.17	1.12
ASDHELN Early Lit Numeracy Activities Before School	Sometimes	8.18	7.30	1.12
	Often	28.83	8.99	3.21**
Homework scale	More involved	1.19	3.29	0.36
ASBH10AA Extra private maths lessons	Yes, to keep up in class	-15.07	4.79	-3.15**
	Yes, to excel in class	-3.39	4.67	-0.73
ASBH10BA Frequency of private maths lessons	Less than 4 months	-0.12	4.98	-0.02
	4-8 months	-0.24	6.98	-0.03
	More than 8 months	2.65	5.17	0.51
ASDGHRL Home Resources for Learning	Some Resources	26.76	3.97	6.73**
	Many Resources	147.11	12.32	11.94**
ASDG05S Number of Home Study Supports	Own Room or Internet Connection	0.32	4.06	0.08
	Both Own Room & Internet Connection	16.62	5.54	3.00**
Discussion: Parental discussions before school started	Moderate discussions	-0.63	4.09	-0.15
	Many discussions	-5.56	5.07	-1.10
ITSEX Gender of child	Male	-12.75	3.31	-3.86**
ITLANG Language of Testing	Afrikaans	-10.82	15.01	-0.72
ASBH19 How often does the child speak the language of the test at home?	Sometimes	124.00	11.24	11.03**
	Almost always	105.07	8.29	12.67**
	Always	38.30	5.98	6.40**

* Significant, $1.96 > t < -1.96 \pm p < 0.05$

** Significant, $2.58 > t < -2.58 \pm p < 0.01$

Parental attitude towards mathematics had no statistically significant relationship with a learners' mathematics score. This finding may be because most of the parents (87%) reported a very positive attitude towards mathematics; therefore, there was no discrimination at the negative end of the scale. Though parental attitude towards mathematics might be important, its effect might be distorted by parents who may think what they have to say was positive. This finding might be a case of social desirability reporting, where respondents tend to respond in a way they feel is socially acceptable. The percentage of South African parents reporting a very positive attitude (87%) was very high compared to the international average of 66% (Mullis et al., 2016).

Compared to other countries who participated in TIMSS 2015 assessment, South African parents were the fourth highest in terms of the percentage of parents with very high positive attitudes (Mullis et al., 2016). Kazakhstan (91%), Indonesia (89%) and Portugal (88%) were the only countries that had a higher percentage of parents having very high positive attitudes compared to South Africa. The top five highest-performing countries in TIMSS 2015, Singapore (79%), Hong Kong (60%), Chinese Taipei (49%), Korean Republic (34%) and Japan (14%) had a lower percentage of parents reporting as having very positive attitudes towards mathematics than parents of South African learners. Even though parental attitudes towards mathematics was a predictor which was not statistically related to mathematics achievement, it was kept in the model because it is part of the conceptual framework, and the analysis is theory driven.

Parental involvement in their children's early numeracy activities before starting school has a statistically significant relationship with the mathematics score. If parents were often involved in their children's numeracy activities before starting school, this could improve their numeracy score by up to 29 score points ($SE = 8.99$). Parental homework involvement is not statistically related to the mathematics score of the learner. Parents might not be going beyond just asking whether the child has done homework since parents might lack the content knowledge to become more involved. The lack of a statistically significant effect of parental homework involvement on learner achievement may also be because parents feel that they have to report that they are involved without them doing that in reality.

Taking a child for private lessons has a statistically significant relationship with the mathematics score to keep up in class. However, this was a negative relationship ($t < -1.96$), which means that attending extra may classes may account for a drop in the mathematics score by 15 score points ($SE = 4.79$). Often, it is the weaker learners who go for private tutoring in mathematics; hence the negative association between receiving private tutoring and achievement may reflect the child's weak grasp of numeracy. Any attempts to rectify the numeracy deficit still point to weaker achievement as these are lower-achieving learners. Weaker learners may be lacking the motivation to do mathematics but may be going to the extra lessons at the behest of their parents. Also, not all children have parents who can afford extra lessons, or such lessons may not be available in deep rural areas. There was no significant relationship between taking a child to private lessons and mathematics achievement if the intention was to excel in class. The frequency with which a child attends extra classes had no significant relationship with the mathematics score.

Availability of resources for learning at home was the strongest predictor of the mathematics achievement score. The difference between learners with few resources and those from homes with some resources was 26 score points ($SE = 3.97$). Learners from households with many resources increased their mathematics achievement with 147 score points ($SE = 12.32$), ($t = 11.94 \ \pm p < 0.01$), which is the equivalence of approximately three years of schooling. Having an own room and internet connection has a statistically significant association with the mathematics score ($t > 1.96$), with a child having their own room with an internet connection increasing the mathematics score by 16 score points ($SE = \ 5.54$). Parental home discussions do not have a statistically significant relationship with mathematics for all the variable categories (-$1.96 < t < 1.96$). The gender of the child may play a part in predicting the mathematics mark of a learner, with boys having a lower achievement than girls. If the learner is a boy, then the model predicts a statistically significant drop of about 13 score points ($SE = 3.31$) in the mathematics marks compared to girls.

The language in which the test was written is not significantly correlated with mathematics achievement. The lack of a statistically significant association between the language of the test and mathematics achievement may have resulted from most learners writing their test in English rather than Afrikaans, causing a lack of discrimination in the variable. However, the frequency with which a child speaks the language of the test at home has a statistically significant relationship with mathematics scores. Speaking the language of test at home “sometimes” when compared to “never” might explain as much as 124 score points ($SE = 11.24$) oF the mathematics score of a learner. Speaking the language of the test almost always at home may predict a further 105 score points (SE=8.29) whilst always speaking the languages at home may add a further 38.3 score points ($SE \ = \ 5.98$) of the mathematics score.

5.4 Conclusion

Chapter 5 looked at the results of the data analysis conducted. Descriptive statistics were presented for both the learner achievement scores and the background variables selected for this study. Factor analysis was done, and the factor loadings for each of the predictor variables were obtained. Factor analysis was done to ascertain the variables which formed a scale, in other words, items that measured the same latent trait. Reliability coefficients were obtained to determine whether the variables consistently measured the construct they intended to measure. In the end, multiple linear regression analysis results were shown.

The descriptive statistics showed a problem of missing values since most of the variables had more than 5% of missing data. Missing data may weaken the statistical power of a study leading to biased findings. Since the listwise deletion method was used, results start getting biased when the percentage of missing data is 5% or more. Responses for the variable on home resources for learning had the biggest missing percentage of 15.5%. From the descriptive statistics, slightly more than half of the parents expected their children to reach a postgraduate degree level. Most parents reported having a positive attitude towards mathematics, with more than eight out of every ten parents saying they were very positive. The majority of parents, 87%, also reported helping their children with mathematics homework.

The linear multiple regression analysis showed that 32% of the variance in the mathematics score (dependent variable) could be explained by the predictor variables in the model. Predictors which showed a statistically significant positive relationship with the mathematics scores were parental expectations, early numeracy activities before school, home resources, amount of home study support and how often a child spoke the language of test at home. The variables which showed a significant negative relationship with mathematics scores were attending private extra mathematics lessons and the gender of the child (male).

Chapter 6
Conclusion and Recommendations

6.1 Introduction

This study used the data for South African learners from the TIMSS Numeracy 2015 assessment to investigate the possible relationship between parental attitudes, beliefs and expectations (ABE) and mathematics achievement of Grade 5 learners. The data used in this study came mainly from the responses that parents provided in the parent questionnaire and the mathematics achievement scores of learners. A few items were also drawn from the learner questionnaire, such as the language of the test and the learner gender.

This final chapter summarises the research (Section 6.2) regarding how the research was conducted and its relevance. Section 6.3 discusses the findings firstly as related to the literature and secondly as related to the conceptual framework and research questions. Section 6.4 covers the contribution of this research study, while Section 6.5 details the limitations of the study. The recommendations from the study are presented in Section 6.6. The researcher's reflections are covered in Section 6.7. Lastly, Section 6.8 details the synthesis and the conclusion.

6.2 Summary of Study

South Africa participated in the TIMSS assessment at the Grade 5 level for the first time in 2015. Internationally, most countries administered the test to learners in Grade 4. South Africa also opted to participate in the easier mathematics assessment, called TIMSS Numeracy 2015, designed for countries whose learners were still developing fundamental numeracy skills (Reddy et al., 2016). However, the achievement of learners participating in TIMSS Numeracy 2015 was reported on the same TIMSS achievement scale as those of the regular mathematics assessment (Reddy et al., 2016).

Competency in mathematics is an important skill, especially in a technology-dependent society. Mathematical understanding prepares and positions a learner for academic and professional development, which may lead to a country's improved welfare and economic growth (Hooper et al., 2013; Isdale et al., 2017). South African learners have consistently performed poorly in mathematics compared to learners from other countries, both at regional and international levels (Isdale et al., 2017; Reddy et al., 2015). This poor performance in mathematics may lead to inequalities in accessing labour markets and disparities in income (Reddy & Hannan, 2018). Though there have been some improvements in mathematics achievement, the gains have happened at the lower end of the scale, which may be attributed to South African learners starting at a much lower base (Spaull, 2013; Spaull & Kotze, 2015).

Chapter 2 described the IEA as well as the TIMSS study in detail. Chapter 2 also explained how TIMSS Numeracy 2015 was conducted in South Africa in terms of sample selection, developing different instruments, and the scoring and reporting of learner achievement. The TIMSS study introduced a parent questionnaire which was completed by parents, to obtain more information about the conditions under which learners live at home.

Research has shown that learner achievement in mathematics is affected by many factors, which may occur at the national, school, learner, and home level (Friedman et al., 2016; Isdale et al., 2017; Reddy et al., 2015). The current study focused on some home level factors which may be associated with learner achievement in mathematics. Parents are the first teachers their children encounter, and parents remain lifelong informal educators. The attitudes of parents towards mathematics are likely to shape a child's attitude towards the subject. Parents who value mathematics and regard it as an important subject are more likely to be involved in their child's schoolwork. How parents view mathematics may also be shaped by the experience which the parents had with the subject when they were still at school (Mbiza, 2018; Mohr-Schroeder et al., 2017).

Several parent-related factors, which may affect mathematics achievement, was discussed in Chapter 3. Parental involvement in learner schoolwork could include helping with homework and also paying for private tutors. Availability of resources at home or SES has consistently been shown to be closely related to learner achievement. The socio-economic disadvantages are more pronounced in South Africa, where two out of three learners come from economically challenged backgrounds (Isdale et al., 2017). Learners from poor backgrounds are the ones who are most likely to attend no-fee paying schools with less qualified mathematics teachers and resources.

6.3 FINDINGS

6.3.1 Findings as related to literature

Consistent with the literature (Geesa et al., 2019; Goodman et al., 2011; Ma & Tse, 2018; Weeransinghe, 2016; Yamamoto & Holloway, 2010), parental expectations were found to have a statistically significant relationship with learner achievement in mathematics. If parents held high expectations about the level of post-school education their children could achieve, the associated score in mathematics increased. However, the findings contradict Madhubela and Bhuvanesari (2016), who found no significant relationship between parental expectations and learner achievement. Parents of Grade 5 learners who participated in TIMSS Numeracy 2015 in South Africa reported very high expectations. Most of the parents said they expected their child to complete a post-graduate degree. The parents who held higher expectations may have supported their child more explicitly and implicitly communicated their belief in their child's abilities. The findings on parental expectations confirm what was obtained by Geesa et al. (2019), namely, that parents in east Asian countries (Japan and South Korea) had very high expectations, which were significantly correlated with their children's higher mathematics achievement. According to the literature (Weerasinghe, 2019; Yamamoto & Holloway, 2010), parental expectations might differ depending on ethnicity and race, which was not explored in this study. Parents should be encouraged to have high expectations for their children and also to communicate these expectations. In turn, parents should be aware of job opportunities that they can connect to higher mathematics achievement. According to the Department of Basic Education (2017), some parents lack the experience and understanding about the importance and value of education and the possibilities that it can unlock the upliftment of one's socio-economic status.

Contrary to what other scholars reported (Areepattamanil et al., 2015; Choi & Han, 2020; Đurišić & Bunijevac 2017; Juan & Visser, 2017, Knap et al., 2016; Maloney et al., 2015; Mohr-Schroeder et al., 2017; Perreira et al., 2014; Soni & Kumari, 2015; Weerasinghe, 2016a), findings from this study showed that parental attitudes towards mathematics are not significantly related to mathematics achievement. However, results for the descriptive statistics for this study showed that South African parents of Grade 5 learners had very positive attitudes, even higher than those of parents in the high performing countries. It is likely that since almost all parents responded as having positive attitudes, this caused a lack of variation on the more negative end of the scale. Maybe the best way to judge if parents have positive attitudes towards mathematics would have been to ask the mathematics teachers how often the parents inquired about their child's performance in the subject. Parents who actively participate in their children's education might be showing more genuine positive attitudes than those answering a questionnaire. For example, Mohr-Schroeder et al. (2017) used the attendance of parents at a "Family Math Night" as a measure of their attitudes towards mathematics.

Early literacy and numeracy activities in which parents participate with a child during pre-school years had some statistically significant positive association with learner achievement in mathematics, a finding which tallies with results from other studies (Clerkin & Gulligan, 2018; Niklas & Schneider, 2014; Segers et al., 2015). Other studies showed that different learners starting Grade 1 in South Africa had diverse numeracy skills, which might mean that those learners who demonstrate higher numeracy skills would have done some numeracy activities at home (Aunio et al., 2016). However, the study by Missal et al. (2015) had discordant results. Though early literacy and numeracy activities are linked with achievement, they depend on the family SES in terms of the level of education of the parents and also the availability of resources to buy things such as number blocks and building blocks that are for developmental activities (Anciano et al., 2020; Le Grange, 2020).

Parental homework involvement was found in this study to have no statistically significant relationship with learner achievement, a finding which contradicts findings of other scholars who reported a positive relationship (Fernandez-Alonso et al., 2016; Jay et al., 2018; Maloney, 2015; Robinson & Harris, 2014; Weerasinghe, 2019). Some scholars found a significant negative association between a lack of parental involvement and achievement (Maroni, 2015; Silinkas & Kikas, 2019). South African parents over-reported helping their children with mathematics homework, which might be a case of social desirability reporting where parents want to portray themselves as helpful to their children. Maloney et al. (2015) also obtained similar responses from parents concerning their homework involvement, where most parents reported helping their children with homework. In the current study, more than 60% of the learners came from disadvantaged backgrounds, which may mean that many parents may not be able to help their children with homework since they may lack the required content knowledge or time. South African parents may only offer homework control as opposed to parental homework support. According to Núñez et al. (2015), parental homework control involves enforcing the writing of homework and making sure there is a punishment if the child does not do homework, while parental homeworking support is when parents help their children do the homework. The Department of Basic Education (DBE) expects parents to check their children’s homework and make them aware that homework is “serious business”, which points to a controlling type of parental involvement (Department of Basic Education, 2017). According to Núñez et al. (2015), if parents are controlling instead of being supportive, then homework involvement does not have a positive relationship with achievement. More qualitative research might be required to understand how South African parents are involved in their children’s homework.

As was expected, availability of home resources for learning showed a significant association with mathematics achievement, which is consistent with other studies conducted (Coleman, 1966; Howie et al., 2017, Isdale et al., 2017; Spaull, 2013; Spaull & Kotze, 2015; Tan et al., 2019). From the results of the descriptive statistics, more than two in every three learners come from households with few resources, which indicates that learners from an impoverished background are at a scholastic disadvantage. Schools may need to find ways to compensate for learner backgrounds by providing enough learning materials and quality education. As enunciated by Coleman (1966) in the Coleman report, improving quality of schools is likely to lead to more improvement for learners from low SES backgrounds when compared to learners from high SES families, a finding corroborated by Spaull and Kotze (2015). The COVID-19 pandemic also exposed the educational inequalities that exist in South Africa. Learners from wealthy backgrounds continued with their learning using online platforms, while learners from poor backgrounds had to stay at home without learning because they lacked the resources needed, for example, devices, electricity, internet connectivity and data (Anciano et al., 2020; Le Grange, 2020). Having an own room and internet connectivity was found to have a statistically significant relationship with mathematics achievement, which underscores the fact that availability of home resources is a good predictor of achievement.

Parental home discussions were found to have no relationship with learner achievement, a finding which is not consistent with what researchers such as Đurišić and Bunijevac (2017), Jay et al. (2018) and Kormanik (2012) found. South African parents may not have time for discussions with their children on matters related to mathematics. The gender of the learner was found in this study to be a significant predictor of mathematics achievement. Girls performed slightly better than boys in mathematics (Isdale et al., 2017; Reddy et al., 2016). Internationally, differences in levels of achievement between girls and boys were not statistically significant (Mullis et al., 2016). Mata et al. (2013) also found that there was no significant difference between the attitude of boys and girls towards mathematics. The focus on the education of the girl child in South Africa could be contributing to the results. The difference may also be a result of girls maturing faster than boys at the Grade 5 level, and as a result, girls may generally be more focused on their schoolwork and doing their homework more than boys (Kristoffersen & Smith, 2013). It may be that because girls show more commitment to their schoolwork than boys, parents and teachers tend to support them more than they do for a boy (Kristoffersen & Smith, 2013).

The frequency at which learners spoke the language of the test at home had a statistically significant relationship with mathematics achievement of the Grade 5 learners, which is consistent with the findings of researchers such as Isdale et al. (2017), Prinsloo et al. (2018), Spaull and Kotze (2015), Taylor and Fintel (2016). Most South African learners wrote the TIMSS assessment in English, yet English is not the language most learners speak at home. Writing the assessment in a language other than the language often spoken at home places most learners at a huge disadvantage (Friedman et al., 2016). According to Mtsatse and Combrinck (2018), there is a trend of code-switching where teachers switch between the language of Learning and Teaching (LoLT) while another language is spoken in the community. Code-switching is a practice that was found to be negatively associated with scholastic achievement (Mtsatse & Combrinck, 2018). Language is also closely linked with other background factors such as SES and social capital. Learners speaking an African language are more likely to come from households lacking basic amenities such as running water, flushing toilets and electricity (Mtsatse & Combrinck, 2018). In South Africa, learners speaking African languages at home are more likely to be from disadvantaged backgrounds and live in homes with low social capital (Prinsloo et al., 2018). Learners who spoke Afrikaans at home and wrote the test in Afrikaans and those who wrote the test in English and used English at home had significantly higher achievement in mathematics (Isdale et al., 2017).

6.3.2 Findings as related to research questions and conceptual framework

The main research question for this study was:

What is the relationship between parental attitudes, parental beliefs and parental expectations about the importance of mathematics and South African Grade 5 learner achievement?

In addressing the main research question, findings from this study showed that *parental attitudes and beliefs* of Grade 5 parents do not have a significant relationship with learner achievement, a finding which contradicts the presumed relationship in the conceptual framework. From the conceptual framework, it was expected that positive parental attitudes would positively affect learner achievement. This study's findings regarding parental attitudes were largely unexpected since they contradict findings from other studies (Choi & Han, 2020; Maloney et al., 2015; Mohr-Schroeder, 2017). In this study, *parental expectations* were found to show a significant relationship with learner achievement in mathematics, a finding which is supported by the conceptual framework that was used in this study. It is important to note that the relationship between parental expectation and learner achievement was only significant if the parents expected their children to complete a postgraduate degree. The findings from the current study indicate that if parents have low expectations about the post-school educational level their child will achieve, then there is no relationship with learner achievement.

- **To what extent is parental encouragement and home discussions related to learner achievement in mathematics**

Contrary to the presumed association in the conceptual framework, parental home discussions were not significantly related to mathematics achievement in this study. This finding may be due to parents not having engaged meaningfully with their children. The question may also have influenced the result since parents tend to overstate the frequency of discussions with their children.

- **To what extent is homework involvement and provision of private tutoring related with learner achievement in mathematics?**

This study showed that the reported frequency at which parents of Grade 5 learners helped their children with homework was not associated with learner achievement in mathematics, contradicting the conceptual framework. The conceptual framework postulated that homework involvement by parents would affect learner achievement either positively or negatively. In the current study, it may be quite possible that parents overstated their level of involvement in their children's mathematics homework. It may also be that parents' involvement in their children's homework was limited to just checking whether the homework had been done. Consistent with the conceptual framework, providing private tutoring had some moderate but significant negative relationship with mathematics achievement. A child who receives mathematics private lessons may be a poor achiever in the subject.

- **Which other background factors have a positive or negative relationship with learner achievement?**

Some background factors were not captured in the conceptual framework but were also investigated for their possible effect on achievement. This study showed a strong link between SES (number of home resources for learning) and mathematics achievement. The relationship between SES and achievement shows that "success begets success", which implies that most South African learners are likely to perform poorly due to their disadvantaged backgrounds. The other background factor linked to SES is home study support which had a moderate relationship with mathematics achievement. The home study support was based on a learner's access to an internet connection and/or their own room. There was evidence of a connection between availability of home study support and learner achievement from this study.

The gender of the child was found to have a significant and negative association with achievement in the case where the learner was male, which implies that girls were performing significantly better in mathematics than boys. This study's results revealed that the frequency at which the language of testing was spoken at home has a significant positive relationship with mathematics achievement. If there is an equivalence between the language spoken at home and the language used for testing, it may be expected that the learner will obtain better results in mathematics. Early literacy and numeracy activities in which parents engaged with the child before enrolment at school were found to have a significant bearing on the mathematics achievement of the child in this study. The more the child was actively involved in early literacy and numeracy activities, the better they achieved in mathematics at school.

6.3.3 Reflections on the Conceptual Framework

The conceptual model used for this study was chosen due to the dearth of conceptual frameworks that adequately captured the relationships between home factors and achievement. Although the conceptual framework used was not an ideal fit, it was the most adequate that could be found. The conceptual framework was difficult to apply to the data, but what has to be kept in mind is that the study was conceptually driven and not data driven. Unlike other studies which make use of large-scale data, this study did not look at this phenomenon systemically (teacher, schools, policy), but focused on a particular aspect of the learner environment.

6.4 Contribution of the Research Study

The current study adds to the body of literature concerning how parents might play a role in their children's mathematics achievement in South Africa. As evidenced by the results from international assessments, South African learners have been performing poorly in mathematics. The current study investigates avenues of the home environment that could be enhanced to improve mathematics achievement. The current study has shown that parents may contribute through high expectations of their child's education, possibly leading to improved mathematics achievement. Awareness campaigns are recommended to conscientise parents on their need to have high expectations of their children. More research may also need to be carried out to establish the possible reasons why parental attitudes were not significantly associated with mathematics achievement in South Africa since this finding is not consistent with results from other studies. There might be a need for types of research that can show variation in parental self-report and limit the effect of social desirability reporting.

This study also showed having parents who assisted their children with homework did not necessarily influence learner achievement in mathematics. Further research might need to be conducted to determine if achievement might not be related to the type of parental homework involvement, whether it is supportive or controlling. Based on the results of this study, the provision of private lessons in order for the child to keep up in class may indicate learners who are struggling, and it is unclear if the extra lessons help learners in the long run.

Early literacy and numeracy activities before a child goes to school should be encouraged, as these activities have been found in this study to have a significant and positive relationship with mathematics achievement. This study found that the relationship between early literacy and numeracy activities and achievement gives impetus to the need to ensure that parents are involved in some activities with their children at home. Ways also need to be found to educate the parents about the exact type of activities which may help their children.

The availability of resources has a large and significant relationship with learner achievement, shown in previous studies and the current study, and is one of the strongest predictors of mathematics achievement. According to Goodman et al. (2011), children from impoverished family backgrounds experience challenging environments from a younger age than their peers, associated with lower cognitive development. Resource deprivation might not be easy to address; schools should be capacitated to aid in ameliorating the impact of home resources for the majority of learners in South Africa. Internet connectivity should be increased in schools so that even learners from poor families may also have access to the internet. With the outbreak of the COVID-19 pandemic and the subsequent disruption of contact learning, the results of this study support the need to help parents and improve resource access, such as more internet connectivity to the poor.

More needs to be done by parents and other stakeholders in South Africa to support the boy child in mathematics since boys are achieving significantly lower than girls. South Africa is one of the few countries which had a significant difference between the achievement of boys and girls (Mullis et al., 2016). In the context of the disadvantaged backgrounds and broken families that most of the learners come from, it might be possible that boys lack guidance and discipline to stay focused. Children from low-income families are more likely to have behavioural problems (Goodman et al., 2011; Kristoffersen & Smith, 2013). The Language of Learning and Teaching (LoLT) is a major barrier for many learners whose home language is different than the medium of instruction. Learners should be taught in their home language until the end of Grade 3, but their mastery of reading and writing in another language might not have sufficiently developed by the time they reach Grade 5, thereby resulting in low achievement. More research is needed on the feasibility of administering the mathematics test in the local home languages. The findings from this study help to highlight the major barriers faced when learning mathematics. The barriers are poverty, the language of learning and teaching (LoTL), historical disadvantage and gender differences. The current study tested for the correlation between different predictors with mathematics achievement. As such, no causal links can be made in the interpretations of the findings (a limitation of the study).

6.5 Limitations of the Study

The reliability of the data may have been affected by the fact that self-reporting questionnaires were used. The use of self-reporting questionnaires has the drawback of social desirability reporting, which may lead to untruthful answers. Over-reporting on the parents' part might have caused distortions in the data due to a lack of variability. The other limitation was the high prevalence of missing data, which weakened the statistical power of the data analysis tools.

The model’s sample was reduced by more than 30% because of missing values. The methodological choices were constrained by the fact that this study was a secondary data analysis, which meant that there was no qualitative data available to understand why parents were responding in the ways they did. Concepts such as parental attitudes, expectations, and other background variables are difficult variables to isolate and measure because they may interact with each other and lack linear relationships. As a result, there is a possibility of other variables not being considered in this study which may be responsible for the results obtained in this study (Goodman et al., 2011). Plausible values were used to approximate learner achievement scores. Even though the use of plausible values is reliable, it is not as reliable as having a learner answer all the questions in the items pool (Clerkin & Gulligan, 2018). It may be important to note that the conceptual framework was designed in a developed country, Australia, whose societies are more homogeneous than the South African context. In South Africa, there are many heterogeneous groups in society concerning living conditions, language, socio-economic status and the legacy of apartheid. This heterogeneity makes the South African context very complex. The complexity also leads to challenges in measurement, especially when using self-reporting questionnaires.

6.6 Recommendations

- **Improving on data collection methods to reduce social desirability reporting from parents**

The unexpected results about the relationship between parental attitudes and homework involvement with mathematics achievement might need further research, such as qualitative research to understand further how parents interact with their children during homework sessions. Other methods of data collection which might mitigate the problem of social desirability need to be explored. Suggestions to reduce social desirability include anonymising results or using Forced Choice Questionnaires (FCQ) in which respondents must rank highly socially desirable items or can only choose a limited number of options/items (Kreitchmann et al., 2019). Alternatives such as FCQs should be explored to enhance the reliability and validity of scales considering the amount of funds and time dedicated to large-scale assessments.

- **Need for schools to activate/have strategies to involve those parents with high expectations for their children actively**

Parents, especially from low-income families, need support and hope that their children will have opportunities to advance their education. Parents need to be aware of how their expectations impact the mathematics achievement of their children. Schools may play a role to ensure that parental expectations are stimulated through engaging parents who already have high expectations for their children.

Even though the results did not support the role of attitudes, positive parental attitudes should be encouraged since other studies have established a link between positive parental attitudes and learner achievement in mathematics. Parent centred intervention programmes have been initiated for parents to raise their expectations, but more can be done in this regard since expectations were found to have a significant relationship with mathematics achievement.

An example of a programme that was started to help young children to develop an interest in reading for meaning is Nal'ibali (meaning "here's the story" in the IsiXhosa language) (Block, 2015; Mubaiwa, 2020). Nal'ibali is an educational non-governmental organisation established by the DG Murray Trust and the Project for the Study of Alternative Education in South Africa

(PRAESA). Nal'ibali promotes the culture of reading by publishing short stories in newspapers and making sure that they are distributed to reading clubs, community organisations, centres for Early childhood Development (ECD), schools, parents, caregivers and community libraries around the country (Mubaiwa, 2020). The stories are also read on the radio. These short stories are translated into different languages. Parents are encouraged to read the stories to their young children or listen as their children read the stories to them. Nal'ibali has had some positive impacts in improving access to reading materials and changing the attitude of parents and children towards reading (Block, 2015; Mubaiwa, 2020).

Another programme was the School-Parent-Community Engagement Framework which the Department of Basic Education initiated to foster working together to enhance learning and achievement by learners (Department of Basic Education, 2017). The framework seeks to increase parental expectations of children and educate parents on being more supportive of their children. The framework also sought to increase schools' understanding of the different backgrounds from which the learners come. If properly implemented, the framework may help increase parental expectations by working hand in hand with other parents in the community and the teachers at schools.

Responsibility to improve mathematics achievement should not be placed on parents alone, but schools have an opportunity to counteract the existing inequalities between learners from poor backgrounds and those from wealthy families. The government should continue supporting disadvantaged schools in terms of resources such as books and internet connectivity to mitigate the effects of a lack of resources on mathematics achievement.

- **The importance of basic foundations, such as early literacy and numeracy activities before school, home study support and adequate resources in a developing context cannot be under-estimated.**

Parents should be encouraged to do all they can possibly do to find the necessary resources needed by their children to do some numeracy activities before they go to school. Policymakers and other educational stakeholders may campaign for all young children to go to early childhood centres where educators may involve the children in numeracy activities. Parents of children from resource-challenged backgrounds might need to be made aware of alternative numeracy activities which are inexpensive. Maybe service providers may need to be lobbied to provide schoolchildren with free internet connectivity. The government should also ensure that schools serving the poor have enough computers and free access to the internet.

- **An asset-based approach to multilingualism is warranted in a developing context, especially where African languages are concerned.**

Efforts should be made to develop and value the local languages so that learners may use their home language as the language of Learning and Teaching (LoLT) until a later age. This approach of developing and valuing African languages will ensure that learners are competent in their home language before learning a different language. Every learner should ideally learn in their home language to avoid being tested twice, first for the language and secondly for the mathematics content (assuming the learner has a primary home language).

6.7 Researcher's Reflections

The researcher has been a mathematics teacher for more than a decade in South Africa and had the chance to teach in a former Model C[9] school, an independent school and a township school. The transition from the independent school to the township school opened the researcher's eyes to the severe challenges that learners from impoverished schools face. Most learners in the township school perform poorly in mathematics, which caused the researcher to be interested in knowing how these learners cope with primary school mathematics. As Graven (2016) puts it, ignoring what happens at the foundation stages is "like insisting that builders lay subsequent layers of bricks on a structurally unsound substratum".

The researcher also noticed that learners in the poor township schools were being provided with stationery, transport to come to school as well as food at school. All these initiatives try and lessen the impact of their poor backgrounds on their educational outcomes. The researcher noted that the mathematics teachers were dedicated and really trying their best as evidenced by very low absenteeism rates among the teachers. The fact that the school was doing all it could to support the learners, albeit with little success in terms of mathematics outcomes, made the researcher wonder if the parents could be more involved to support their children's mathematics learning. The poor performance of learners in mathematics may be caused by an interplay of factors where no single factor may be isolated in a socially complex context such as the ones where the researcher worked.

6.8 Synthesis and Conclusion

Mathematics is an important subject that may open the doors to many rewarding careers (Geesa et al., 2019). Unfortunately, South African learners have been poor performers in mathematics compared to children from other countries within the region or internationally (Spaull, 2013). The poor performance by South Africa is even though the government spends comparatively high amounts on education and has the political will to identify the gaps and

[9] Formerly semi-private government schools which were for white learners during apartheid in South Africa.

seek redress (Graven, 2016). Though the focus has mainly been at the school level to improve the mathematics outcomes, this study also looked at the home level, what parents might do to improve their children's achievement in mathematics. This study aimed to examine the relationship between parental attitudes, beliefs and expectations and mathematics achievement. Other background variables were also investigated to find the significant relationships with mathematics achievement and control for background variables. South Africa’s TIMSS Numeracy 2015 data was used.

Higher parental expectations may lead to better mathematics outcomes. Therefore, it is important to encourage parents to have high expectations and share these expectations with their children. However, researchers should also conduct further studies to understand what drives parental expectations. Based on the findings from this study, parents are not passive participants in their children’s mathematics learning but may play a role through participating in activities at home with their children, which may enhance their children’s literacy and numeracy skills before they go to school. Even though it is challenging, parents should provide support to their children by availing themselves and, if economically possible, more home resources that may be required for learning. Without adequate resources, the chances of their children succeeding in mathematics are significantly diminished. Most South African learners come from low-income families, and unless there are concrete efforts to alleviate poverty, South Africa may find itself trapped in the cycle of poor mathematics achievement. Lastly, the majority of South African learners suffer the double disadvantage of poverty and learning and writing mathematics in a second language. Many learners might fail mathematics not exclusively due to weak content knowledge but also because they might not understand the language in which they learn and write mathematics.

Results from this study may present opportunities to policymakers and scholars to search for a deeper understanding of how parental attitudes, beliefs and expectations are related to mathematics achievement and how these affective domains may be strengthened in families.

List of References

Adamuti-Trache, M., Sweet, R., Mandell N., and Anisef, P. (2007). *Managing the home learning environment: Parents, adolescents, and the homework problem.* Canadian Council on Learning.

Alkharusi, H. (2012). Categorical variables in regression analysis: A comparison of dummy and effect coding. *International Journal of Education*, *4*(2), 202. https://doi.org/10.5296/ije.v4i2.1962

Ally, N. & McLaren, D. (2016). *Fees are an issue in school too, not just university*. https://projectrise.news24.com/fees-issue-school-not-just-university/

Amnesty International. (2020). *Broken and unequal: The state of education in South Africa*.

Anciano, F., Cooper-Knock, S., Dube, M., Majola, M., & Papane, B. (2020). COVID-19 exposes South Africa's unequal schooling system. *.Africa at LS*

Areepattamannil, S. (2010). Parenting practices, parenting style, and children's school achievement. *Psychological Studies, 55*(4), 283-289. https://doi.org/10.1007/s12646-010-0043-0

Areepattamannil, S., Khine, M. S., Melkonian, M., Welch, A. G., Al Nuaimi, S. A., & Rashad, F. F. (2015). International note: Are Emirati parents' attitudes toward mathematics linked to their adolescent children's attitudes toward mathematics and mathematics achievement?. *Journal of Adolescence*, *44*, 17-20. https://doi.org/10.1016/j.adolescence.2015.07.002

Arends, F., Winnaar, L., & Mosimege, M. (2017). Teacher classroom practices and Mathematics performance in South African schools: A reflection on TIMSS 2011. *South African Journal of Education*, *37*(3), 1-11. https://doi.org/10.15700/saje.v37n3a1362

Aunio, P., Mononen, R., Ragpot, L., & Törmänen, M. (2016). Early Numeracy Performance of South African School Beginners. *South African Journal of Childhood Education*, *6*(1), 8. https://doi.org/10.4102/sajce.v6i1.496

Bird, F. (2020). A defense of objectivity in the social sciences, rightly understood. *Sustainability: Science, Practice and Policy*, *16*(1), 83-98. https://doi.org/10.1080/15487733.2020.1785679

Bloch, C. (2015). *Nal'ibali and libraries: activating reading together*. http://library.ifla.org/1282/1/076-bloch-en.pdf

Block, D. (2015). Becoming multilingual and being multilingual: some thoughts. *Multilingual Education*, 225.

Bourdieu, P. (2008). The Forms of capital. In AR Sadovnik (ed.), *Sociology of education: A Critical Reader* (pp 83-95). Routledge.

Boslaugh, S. (2007). *Secondary analysis for public health: A practical guide.* Cambridge University Press.. https://doi.org/10.1017/CBO9780511618802.

Branson, N., & Zuze, T. L. (2012). Education, the great equaliser: Improving access to quality education. *South African Child Gauge*, *2012*, 69-74. http://www.ci.org.za/depts/ci/pubs/pdf/general/gauge2012/education_equaliser.pdf

Cai, J., Moyer, J. C., & Wang, N. (1999). Parental roles in Students' Learning of Mathematics: An Exploratory Study. *Research in Middle Level education Quarterly*, 22(3), 1-18.

Caño, K.J., Cape, M.G., Cardosa, J.M., Miot, C., Pitogo, G.R., & Merin, C.M.Q.J. (2016). Parental Involvement On Pupils' Performance: Epstein's Framework. *The Online*

Journal of New Horizons in Education, 6(4). https://www.tojned.net/journals/tojned/volumes/tojned-volume06-i04.pdf#page=151

Caputo, A. (2017). Social desirability bias in self-reported well-being measures: Evidence from an online survey. *Universitas Psychologica*, *16*(2), 245-255. https://doi.org/10.11144/javeriana.upsy16-2.sdsw

Centre for Development and Enterprise (2013). *Extra Maths Tuition in South Africa A short summary of an exploratory investigation*. https://www.cde.org.za/wp-content/uploads/2018/07/Extra-maths-tuition-in-South-Africa-a-short-summary-of-an-exploratory-investigation.pdf.

Cheema, J. R. (2014). Some general guidelines for choosing missing data handling methods in educational research. *Journal of Modern Applied Statistical Methods*, *13*(2), 53-75. https://doi.org/10.22237/jmasm/1414814520

Chen, W. & Gregory, A. (2009). Parental involvement as a protective factor during the transition to high schools. *The Journal of Educational Research, 103(1), 53-62.* https://doi.org/10.1080/00220670903231250

Cheo, R. & Quah, E. (2005). Mothers, Maids and Tutors: An Empirical Evaluation of Their Effect on Children's Academic Grades in Singapore. *Education Economics, 13(*3), 269- 285. https://doi.org/10.1080/09645290500073746

Choi, J., & Han, H. (2020). Do Parental Attitudes Really Matter to Children's Mathematics Anxiety? A meta-Analysis. *Universal Journal of Educational Research 8(5) 1731-1740.* https://doi.org/10.13189/ujer.2020.080509

Clark, N. L., & Worger, W. H. (2011). *South Africa: the rise and fall of apartheid* (2nd ed). Longman.

Clerkin, A., & Gilligan, K. (2018). Pre-school numeracy play as a predictor of children's attitudes towards mathematics at age 10. *Journal of Early Childhood Research*, *16*(3), 319-334. https://doi.org/10.1177/1476718x18762238

Cohen, J. W. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Lawrence Erlbaum Associates.

Cole, R. (2017). Estimating the impact of private tutoring on academic performance: primary students in Sri Lanka. *Education Economics*, *25*(2), 142-157. https://doi.org/10.1080/09645292.2016.1196163

Coleman, J. S. (1966). *Equality of educational opportunity [summary report]*. Washington: U.S. Dept. of Health, Education, and Welfare, Office of Education. United States., & National Center for Education Statistics.

Demetriou, C., Ozer, B. U., & Essau, C. A. (2014). Self-report questionnaires. *The Encyclopedia of Clinical Psychology*, 1-6.

Department of Basic Education. (2016). *Practical guidelines: How parents can contribute meaningfully to the success of their children in schools.* https://www.education.gov.za/Portals/0/Documents/Publications/parents/Parent%20Practical%20Guidelines.pdf?ver=2018-06-08-094707-360#:~:text=Teach%20their%20children%20discipline%20and,positive%20relationship%20with%20their%20children.

Department of Basic Education. (2017). School - Parent – Community Engagement Framework. https://www.education.gov.za/Portals/0/Documents/Publications/Principals/PARENTCOMMUNITY3print2.pdf?ver=2018-06-08-094733-270

Department of Education. (2006). *Regulations Relating to the Exemption of Parents from Payment of School Fees in Public Schools. Published in terms of the South African*

Schools Act, No. 84 of 1996. Department of Education. https://www.gov.za/sites/default/files/gcis_document/201409/act84of1996.pdf

Doolan, D. M., & Froelicher, E. S. (2009). Using an existing data set to answer new research questions: A methodological review. *Research and Theory for Nursing Practice: An International Journal,* 23(3), 203-215. https://doi.org/10.1891/1541-6577.23.3.203

Dufur, M. J., Parcel, T. L., & Troutman, K. P. (2013). Does capital at home matter more than capital at school? Social capital effects on academic achievement. *Research in Social Stratification and Mobility, 31, 1-21.* https://doi.org/10.1016/j.rssm.2012.08.002

Dumont, H., Trautwein, U., Lüdtke, O., Neumann, M., Niggli, A., & Schnyder, I. (2012). Does parental homework involvement mediate the relationship between family background and educational outcomes?. *Contemporary Educational Psychology*, 37, 55–69. https://doi.org/10.1016/j.cedpsych.2011.09.004 .

Durisic, M., & Bunijevac, M. (2017). Parental involvement as an important factor for successful education. *Center for Educational Policy Studies Journal*, 7(3), 137-153.

Eagle, E. (1989). Socioeconomic status, family structure, and parental involvement: The correlates of achievement. *Paper presented at the American Education Research Association*, San Francisco, CA. ERIC Document Reproduction Service No. E 307 332.

Ebbs, D. & Korsnakova, P. (2016). Translation and Translation Verification for TIMSS 2015. In M. O. Martin, I. V. S. Mullis & M. Hooper (Eds.), *Methods and Procedures in TIMSS 2015* (pp. 7.1-7.16). TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Epstein, J. (2002). *School, family, and community partnerships: Preparing educators and improving schools*. Westview Press.

Eriksson, K., Helenius, O., & Ryve, A. (2019). Using TIMSS items to evaluate the effectiveness of different instructional practices. *Instructional Science*, *47*(1), 1-18. https://doi.org/10.1007/s11251-018-9473-1

European Union, (2014). Study on the effective use of early childhood education and care in preventing early school leaving. http://www.cccw.ie/wp-content/uploads/2014/04/Effective-use-of-early-childhood-education-and-care-in-preventing-early-school-leaving-Final-Report.pdf

Fan, X. & Chen, M. (2001). Parental involvement and students academic achievement: A meta-analysis. *Educational Psychology Review, 13*, 26-61. https://www.springer.com/journal/10648#:~:text=Educational%20Psychology%20Review%20is%20an,to%20the%20field%20of%20educational

Fan, W., & Wolters, C. (2014). School motivation and high school dropout: The mediating role of educational expectation. *British Journal of Educational Psychology*, (84)1, 22-39. https://doi.org/10.1111/bjep.12002

Fernández-Alonso, R., Suárez-Álvarez, J., & Muñiz, J. (2015). Adolescents' homework performance in mathematics and science: Personal factors and teaching practices. *Journal of Educational Psychology*, *107,* 1075- 1085. https://doi.org/10.1037/edu0000032

Fernández-Alonso, R., Suárez-Álvarez, J., & Muñiz, J. (2016). Homework and performance in mathematics: The role of the teacher, the family and the student's background. *Revista de Psicodidáctica, 21*(1), 5-23. https://doi.org/10.1387/revpsicodidact.13939

Field, A. P. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.

Fiske, E. B., & Ladd, H. F. (2004). Balancing public and private resources for basic education: school fees in post-apartheid South Africa. *Changing class: Education and social change in post-apartheid South Africa*, 57-88. https://www.researchgate.net/profile/Helen-Ladd/publication/228860805_Balancing_Public_and_Private_Resources_for_Basic_Education_School_Fees_in_Post-Apartheid_South_Africa/links/0deec51e3fe8190701000000/Balancing-Public-and-Private-Resources-for-Basic-Education-School-Fees-in-Post-Apartheid-South-Africa.pdf

Foy, P., Martin, M. O., Mullis, I. V. S., Yin, L., Centurino, V. A. S. & Reynolds, K. A. (2016). Reviewing the TIMSS 2015 Achievement Item Statistics. In M. O. Martin, I. V. S. Mullis & M. Hooper (Eds.), *Methods and Procedures in TIMSS 2015* (pp. 11.11-11.43). Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Friedman, T., Schwantner, U., Spink, J., Tabata N., & Waters, C. (2016). *Improving Quality of Education and Children's Learning Outcomes and Effective Practices in Eastern and Southern Africa Region: Main report*. Australian Council for Educational Research (ACER).

Geesa, R. L., Izci, B., Song, H., & Chen, S. (2019). Exploring factors of home resources and attitudes towards mathematics in mathematics achievement in South Korea, Turkey, and the United States. *EURASIA Journal of Mathematics, Science and Technology Education*, *15*(9). https://doi.org/10.29333/ejmste/108487

Goodman, A., Gregg, P., & Washbrook, E. (2011). Children's educational attainment and the aspirations, attitudes and behaviours of parents and children through childhood. *Longitudinal and Life Course Studies*, *2*(1), 1-18. https://doi.org/10.14301/llcs.v2i1.147

Graven, M. H. (2014). Poverty, inequality and mathematics performance: The case of South Africa's post-apartheid context. *ZDM*, *46*(7), 1039-1049. https://doi.org/10.1007/s11858-013-0566-7

Graven, M.H., (2016). When systemic interventions get in the way of localised reform. *For the Learning of Mathematics, 36*(1), 8–13. https://www.ru.ac.za/media/rhodesuniversity/content/sanc/documents/Graven_-_2016_-_When_systemic_interventions_get_in_the_way_of_localized_mathematics_reform.pdf

Gronmo, L. S., Lindquist, M., Arora, A., & Mullis, I. V. (2015). TIMSS 2015 mathematics framework. *TIMSS*, 11-27.

Grossman, J. A., Kuhn-McKearin, M., & Strein, W. (2011). Parental Expectations and Academic Achievement: Mediators and School Effects. *Annual Convention of the American Psychological Association, 4.*

Guba, E.G. & Lincoln, Y.S. (1994). Competing paradigms in qualitative research. In N.K. Denzin & Y.S. Lincoln (Eds.). *Handbook of qualitative research*, (2nd ed., pp. 105–117). SAGE.

Guill, K. & Lintorf, K. (2019). Private tutoring when stakes are high: Insights from the transition from primary to secondary school in Germany. *International Journal of*

Educational Development, *65,* 172-182. https://doi.org/10.1016/j.ijedudev.2018.08.001.

Gustafsson, J. E., Hansen, K. Y., & Rosén, M. (2011). Effects of home background on student achievement in reading, mathematics, and science at the fourth grade. *Timss and Pirls*, *4*, 181-287. https://timssandpirls.bc.edu/

Hammersley, M. (2019). From Positivism to Post-Positivism: Progress or Digression?. *Teoria Polityki*, (3), 175-188. https://doi.org/10.4467/25440845tp.19.009.10292

Hannula, M. S. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics, 49, 25–46.* https://www.jstor.org/stable/3483259

Harju-Luukkainen, H., Vettenranta, J., Wang, J., & Garvis, S. (2020). Family related variables effect on later educational outcome: a further geospatial analysis on TIMSS 2015 Finland. *Large-scale Assessments in Education*, *8*(1), 1-13. https://doi.org/10.1186/s40536-020-00081-2

Hart, S. A., Ganley, C. M., & Purpura, D. J. (2016). Understanding the home math environment and its role in predicting parent report of children's math skills. *PloS one*, *11*(12), e0168227. https://doi.org/10.1371/journal.pone.0168227

Heaton, T. B., Amoateng, A. Y., & Dufur, M. (2014). Race differences in educational attainment of youth aged 7-18 in post-apartheid South Africa: The role of family structure, resources and school quality. *South African Review of Sociology, 45(1), 101- 121.* https://doi.org/10.1080/21528586.2014.887917

Henderson, K. A. (2011). Post-positivism and the pragmatics of leisure research. *Leisure Sciences*, *33*(4), 341-346. https://doi.org/10.1080/01490400.2011.583166

Henry, C. S., Plunkett, S. W., & Sands, T. (2011). Family structure, parental involvement, and academic motivation in Latino adolescents. *Journal of Divorce & Remarriage, 52(6), 370-390.* https://doi.org/10.1080/10502556.2011.592414

Hill, N. E. & Chao, R. K. (2009). Families, schools, and the adolescent: Connecting research, policy, and practice. *Adolescence, 44(176), 1047-1049*.

Hill, N. E. & Torres, K. E. (2010). Negotiating the American dream: The paradox of aspirations and achievement among Latino students and engagement between their families and schools. *Journal of Social Issues, 66(1), 95-112.* https://spssi.onlinelibrary.wiley.com/journal/15404560

Hodaňová, J., & Nocar, D. (2016). Mathematics importance in our life. In *Conference: 10th annual International Technology, Education and Development Conference (INTED2016), At Valencia, Volume: INTED2016 Proceedings* (pp. 3086-30863092).

Hooper, M., Mullis, I. V. S. & Martin, M. O. (2013). TIMSS 2015 Context Questionnaire Framework. In I. V. S. Mullis & M. O. Martin (Eds.), *TIMSS 2015 Assessment Frameworks* (pp. 61-84). TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Hoover-Dempsey, K. V., & Sandler, H. M. (2005). *Final performance report for OERI Grant# R305T010673: The social context of parental involvement: A path to enhanced achievement*. https://ir.vanderbilt.edu/bitstream/handle/1803/7595/OERIIESfinalreport032205.pdf?sequence=1&isAllowed=y

Howie, S. J., Combrinck, C., Tshele, M., Roux, K., McLeod Palane, N. & Mokoena, G. M. (2017*). PIRLS 2016: Progress in International Reading Literacy study 2016: South African children's reading literacy achievement.* Centre for Evaluation and Assessment (CEA), Faculty of Education, University of Pretoria.

Howie, S. (2004). A national assessment in mathematics within an international comparative assessment. *Perspectives in Education*, *22*(2), 149-162. https://hdl.handle.net/10520/EJC87251

Howie, S. J., van Staden, S., Tshele, M., Dowse, C., & Zimmerman, L. (2012). *South African Children's Reading literacy achievement summary report.* Centre for Evaluation and Assessment.

Hu, J., Dong, X. & Peng, Y. (2021). Discovery of the key contextual factors relevant to the reading performance of elementary school students from 61 countries/regions: insight from a machine learning-based approach. *Read Writ* (2021). https://doi.org/10.1007/s11145-021-10176-z Institute of Race Relations. (2019). *Race relations in South Africa. Reasons for hope*. https://irr.org.za/reports/occasional-reports/files/reasons-for-hope-report-final.pdf.

International Association for the Evaluation of Educational Achievement (IEA). (2017a). About IEA. Retrieved 11 March 2019 from http://www.iea.nl/about-us)

International Association for the Evaluation of Educational Achievementeus). (2017b). Brief History of the IEA. Retrieved 15 April 2019 from http://www.iea.nl/brief-history-iea)

Isdale, K., V. Reddy, A. Juan, & F. Arends. (2017). *TIMSS 2015 Grade 5 National Report: Understanding Mathematics Achievement Amongst Grade 5 Learners in South Africa.* http://ecommons.hsrc.ac.za/handle/20.500.11910/11847

Islam, M. D., & Khan, Z. (2017). The impact of socio-economic status on academic achievement among the senior secondary school students. *An International Journal of Education and Applied Social Sciences*, 8. 1-7. https://doi.org/10.5958/2230-7311.2017.00117.9.

Jacobs, J. E., & Eccles, J. S. (1992). The impact of mothers' gender-role stereotypic beliefs on mothers' and children's ability perceptions. *Journal of Personality and Social Psychology*, *63*(6), 932 - 944. https://doi.org/10.1037/0022-3514.63.6.932

Jakhar, L. R. (2019). Influence of parental encouragement on the emotional maturity of mathematics students. *The Educational Beacon, 8.* http://www.theeducationalbeacon.com/

Jameel, B., Shaheen, S. & Majid, U. (2018). Introduction to qualitative research for novice investigators. *Undergraduate Research in Natural and Clinical Sciences and Technology Journal*, 2, 1-6. https://www.urncst.com/index.php/urncst

Jay, T., & Xolocotzin, U. (2012). Mathematics and economic activity in primary school children. In *Proceedings of the 36th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 331-338).

Jay, T., Rose, J., & Simmons, B. (2013). Why parents can't always get what they (think they) want. *Proceedings of the British Society for Research into Learning Mathematics*, *33*(2), 31–36. https://publons.com/journal/287775/proceedings-of-the-british-society-for-research-in/

Jay, T., Rose, J., & Simmons, B. (2017). Finding 'mathematics': parents questioning school-centred approaches to involvement in children's mathematics learning. *School Community Journal, 27(1), 201-230.* https://files.eric.ed.gov/fulltext/EJ1146482.pdf

Jay, T., Rose, J., & Simmons, B. (2018). Why is parental involvement in children's mathematics learning hard? Parental perspectives on their role supporting children's learning. *Sage Open* 8 (2), 1–13. htpps://doi.org/10.1177/2158244018775466

Jeynes, W. H. (2010a). *Parental involvement and academic success*. Routledge.

Jeynes, W. (2011). *Parental involvement and academic success*. Routledge.

Johansone, I. (2016). Survey Operations Procedures in TIMSS 2015. In M. O. Martin, I. V. S. Mullis & M. Hooper (Eds.), *Methods and Procedures in TIMSS 2015* (pp. 6.1-6.22). TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Johnston, M. (2014). Secondary data analysis: A method of which the time has come. *Qualitative and Quantitative Methods in Libraries*, 3(3), 619-626. http://www.qqml.net/index.php/qqml

Jojo, Z. (2019). Mathematics Education System in South Africa. In *Education Systems Around the World*. IntechOpen. https://www.intechopen.com/chapters/67007

Juan, A. & Visser, M. (2017). Home and school environmental determinants of science achievement of south african students. *South African Journal of Education*, *37*(1), 1–10. https://doi.org/10.15700/saje.v37n1a1292

Juan, A., Hannan, S., Zulu, N., Prinsloo, C., Mosimege, M., Harvey, J. et al. (2017). TIMSS *Item Diagnostic Report: South Africa Grade 5 Numeracy. Report submitted to the Department of Basic Education (DBE).* Department of Basic Education.

Khan, A., & Zahidullah, I. A. (2017). Investigation into Parents' Attitude towards Mathematics for Girls at Intermediate Level in FATA. *International Journal of Academic Research in Education and Development,* 6(4), 123-139. http://dx.doi.org/10.6007/IJARPED/v6-i4/3752

Knapp, A., Landers, R., & Liang, S. (2016). H How does parental attitude toward mathematics prompt student achievement. In *Proceedings of the 38th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 1107-1110).

Kormanik, K. (2012). *A greater role in math education for parents: mathematical reasoning at home.* https://edsource.org/2012/a-greater-role-in-math-education-for-parents-mathematical-reasoning-at-home/23918.

Kreitchmann, R. S., Abad, F. J., Ponsoda, V., Nieto, M. D., & Morillo, D. (2019). Controlling for response biases in self-report scales: forced-choice vs. psychometric modeling of likert items. *Frontiers in Psychology, 10*, 2309–2309. https://doi.org/10.3389/fpsyg.2019.02309.

Kristoffersen, J. & Smith, N. (2013). Gender Differences in the Effects of Behavioural Problems on School Outcomes, IZA Discussion Papers 7410, Institute of Labor Economics, Aarhus University (IZA). http://hdl.handle.net/10419/80682

Kruger, G. M. (2015). *The relationship between investment in ICT and mathematics achievement*. (Doctoral thesis), University of Pretoria, Pretoria, South Africa.) https://repository.up.ac.za/bitstream/handle/2263/67752/Kruger_Relationship_2018.pdf?sequence=1

Kundu, S. C., & Kar, S. (2018). *Mathematics anxiety and its relationship with the achievement of Secondary school students*. http://ijrar.com/upload_issue/ijrar_issue_1674.pdf.

LaRoche, S. & Foy, P. (2016). Sample Implementation in TIMSS 2015. In M. O. Martin, I. V. S. Mullis & M. Hooper (Eds.), *Methods and Procedures in TIMSS 2015* (pp. 5.1-5.175). TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

LaRoche, S., Joncas, M., & Foy, P. (2016). Sample Design in TIMSS 2015. In M. O. Martin, I. V. S. Mullis, & M. Hooper (Eds.), *Methods and Procedures in TIMSS 2015* (pp. 3.1-3.37). http://timss.bc.edu/publications/timss/2015-methods/chapter-3.html

Laukaityte, I., & Wiberg, M. (2017). Using plausible values in secondary analysis in large-scale assessments. *Communications in statistics-Theory and Methods*, *46*(22), 11341-11357. https://doi.org/10.1080/03610926.2016.1267764

Lawrence, A. S., & Barathi, C. (2016). Parental Encouragement in Relation to Academic Achievement of Higher Secondary School Students. *International Journal of Advance Research and Innovative Ideas in Education*, 2(6), 1234-1239. https://files.eric.ed.gov/fulltext/ED571491.pdf

Lazarides, R., Harackiewicz, J., Canning, E., Pesu, L., & Vilaranta, J. (2015)The role of parents in students' motivational beliefs and values. In *Routledge International Handbook of Social Psychology of the Classroom*, (pp. 81-94). Routledge.

Lazarides, R., Viljaranta, J., Aunola, K., Pesu, L., & Nurmi, J. E. (2016). The role of parental expectations and students' motivational profiles for educational aspirations. *Learning and Individual Differences*, *51*, 29-36. https://doi.org/10.1016/j.lindif.2016.08.024

Ledesma, R. D., Valero-Mora, P., & Macbeth, G. (2015). The Scree test and the number of factors: a dynamic graphics approach. *The Spanish Journal of Psychology*, *18*. https://doi.org/10.1017/sjp.2015.13

Lee, J. Y. (2013). *Private tutoring and its impact on students' academic achievement, formal schooling and educational inequality in Korea*. {PhD dissertation, Columbia University.)

Lee, J., & Bowen, N. K. (2006). Parent involvement, cultural capital, and the achievement gap among elementary school children. *American Educational Research Journal, 43(2), 193-218.* https://doi.org/10.3102/00028312043002193

Legner, P. (2013). The value of teaching mathematics. http://mathigon.org/resources/valueof-mathematics.pdf

Le Grange, L. (2020). COVID-19 pandemic and the prospects of education in South Africa. *Prospects*, 1-12. https://doi.org/10.1007/s11125-020-09514-w

Lemmer, E. M. (2007). Parent involvement in teacher education in South Africa. *International Journal about Parents in Education*, 1, 218–229. https://www.ernape.org/journal/#:~:text=The%20International%20Journal%20about%20Parents,parents%20in%20Education%20(ERNAPE).

Leopold, T. A., Ratcheva, V., Zahidi, S., & Samans, R. (2017). *The future of jobs and skills in Africa: preparing the region for the Fourth Industrial Revolution*. World Economic Forum. http://www3. weforum. org/docs/WEF_EGW_FOJ_Africa. pdf.

Llamas, A. V. & Tuazon, A. P. (2016). School practices in parental involvement, its expected results and barriers in public secondary schools*. International Journal of Educational Science and Research*, 6(1), 69-78. http://www.tjprc.org/journals/international-journal-of-scientific-research

Ma, Y., Siu, A., & Tse, W. S. (2018). The role of high parental expectations in adolescents' academic performance and depression in Hong Kong. *Journal of family issues*, *39*(9), 2505-2522. https://doi.org/10.1177/0192513x18755194

Machebe, C. H., Ezegbe, B. N., & Onuoha, J. (2017). The Impact of Parental Level of Income on Students' Academic Performance in High School in Japan. *Universal Journal of Educational Research*, *5*(9), 1614-1620. https://doi.org/10.13189/ujer.2017.050919

Madhubala, M., & and Bhuvaneswari, R. (2016). Influence of parental expectation on academic achievement of secondary school students. *International Journal Research of India*, 2(3). https://www.worldwidejournals.com/paripex/

Mahanta, D. (2014). The role of home environment and mathematics achievement for students of secondary schools in Nagaon District. *Asian Journal of Advanced Basic Science*, *2*(1), 105-115. https://journals.indexcopernicus.com/search/details?id=31967

Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science*, 26(9), 1480–1488. https://doi.org/10.1177/0956797615592630

Mansour, M., & Martin, A. J. (2009). Home, parents, and achievement motivation: A study of key home and parental factors that predict student motivation and engagement. *Australian Educational and Developmental Psychologist, 26*, 111-126. https://doi.org/10.1375/aedp.26.2.111

Maree, K. (2016). *First Steps in research* (2nd ed.). Van Schaik.

Martin, M.O., Mullis, I.V.S & Hooper, M. (2016). *Methods and Procedures in TIMSS 2015* (pp. 10.11).http://timss.bc.edu/publications/timss/2015-methods/chapter-10.html

Martin, M. O., & Mullis, I. V. S. (2008). *Ensuring comparative validity: Quality control in IEA studies*. TIMSS & PIRLS: International Study Center: Lynch School of Education.

Martin, M. O., Mullis, I. V. S., Hooper, M., Yin, L., Foy, P., & Palazzo, L. (2016). Creating and Interpreting the TIMSS 2015 Context Questionnaire Scales. In M. O. Martin, I. V. S. Mullis, & M. Hooper (Eds.), *Methods and Procedures in TIMSS 2015* (pp. 15.1-15.312). http://timss.bc.edu/publications/timss/2015-methods/chapter-15.html

Martin, M. O., Mullis, I. V., & Hooper, M. (2016). Methods and procedures in TIMSS 2015. *TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College and International Association for the Evaluation of Educational Achievement (IEA)*.

Martins, F. S., da Cunha, J. A. C., & Serra, F. A. R. (2018). Secondary data in research–uses and opportunities. *PODIUM Sport, Leisure and Tourism Review*, *7*(3), I-IV. https://doi.org/10.5585/podium.v7i3.316

Mata, M. D. L., Monteiro, V., & Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *Child Development Research, 2012,1–10.* https://doi.org/10.1155/2012/876028

Mbiza, M. (2018). The apartheid segregation plan of education. https://www.dailymaverick.co.za/opinionista/2018-11-02-the-apartheid-segregation-plan-of-education/.

Mbugua, K. Z., Kibet, K., Muthaa, M, G. & Nkonke, R. G. (2012). Factors Contributing to Students' Poor Performance in Mathematics at Kenya Certificate of Secondary Education in Kenya: A case of Baringo Country, Kenya. *American International Journal of Contemporary Research*, *2*(6), 87-91. https://aijcrnet.com/

McDowall, P.S. & Schaughency, E. 2017. Elementary school–parent engagements: Relations with education perceptions and school characteristics. *Journal of Educational Research*, *110(*4), 348–365. https://doi.org/10.1080/00220671.2015.1103687

McKeever, M. (2017). Educational inequality in apartheid South Africa. *American Behavioral Scientist*, *61*(1), 114-131. https://doi.org/10.1177/0002764216682988

McMillan, J. H. (2016). *Fundamentals of Educational Research* (7th ed.). Pearson.

Meier, C., & Lemmer, E. (2015). What do parents really want? Parents' perceptions of their children's schooling. *South African Journal of Education*, *35*(2), 1-11. https://doi.org/10.15700/saje.v35n2a1073

Meyer, S., Cockle, M. & Taneva, M. (2016). Creating the TIMSS 2015 International Database. *Methods and Procedures in TIMSS*.

Missall, K., Hojnoski, R. L., Caskie, G. I., & Repasky, P. (2015). Home numeracy environments of preschoolers: Examining relations among mathematical activities, parent mathematical beliefs, and early mathematical skills. *Early Education and Development*, *26*(3), 356-376. https://doi.org/10.1080/10409289.2015.968243

Mji, A., & Makgato, M. (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. http://www.sajournalofeducation.co.za/index.php/saje

Mlachila, M., & Moeletsi, T. (2019). *Struggling to make the grade: A review of the causes and consequences of the weak outcomes of South Africa's education system*. https://www.imf.org/-/media/Files/Publications/WP/2019/WPIEA2019047.ashx.

Mmotlane, R., Winnaar, L., & Wa Kivilu, M. (2009). Personal characteristics that predict South Africans' participation in activities of their children's schools. *South African Journal of Education, 29(4), 527-540.* https://doi.org/10.15700/saje.v29n4a294

Mncube, V. 2010. Parental involvement in school activities in South Africa to the mutual benefit of the school and the community. *Education as Change*, *14*(2), 233-246. https://doi.org/10.10 80/16823206.2010.522061

Mohajan, H. K. (2017). Two criteria for good measurements in research: Validity and reliability. *Annals of Spiru Haret University. Economic Series*, *17*(4), 59-82. https://doi.org/10.26458/1746

Mohr-Schroeder, M. J., Jackson, C., Cavalcanti, M., Jong, C., Craig Schroeder, D., & Speler, L. G. (2017). Parents' Attitudes Toward Mathematics and the Influence on Their Students' Attitudes toward Mathematics: A Quantitative Study. *School Science and Mathematics*, *117*(5), 214-222. https://doi.org/10.1111/ssm.12225

Moroni, S., Dumont, H., Trautwein, U., Niggli, A., & Baeriswyl, F. (2015). The need to distinguish between quantity and quality in research on parental involvement: The example of parental help with homework. *The Journal of Educational Research*, *108*(5), 417-431. https://doi.org/10.1080/00220671.2014.901283

Munje, P. N. & Mncube, V. (2018). The lack of parent involvement as hindrance in selected public primary schools in South Africa: The voices of educators. *Perspectives in Education*, *36(*1), 80–93. https://doi.org/10.18820/2519593x/pie.v36i1.6

Msila, V. (2007). From apartheid education to the Revised National Curriculum Statement: Pedagogy for identity formation and nation building in South Africa. *Nordic Journal of African Studies*, *16*(2). http://www.njas.helsinki.fi/pdf-files/vol16num2/msila.pdf

Mtsatse, N., & Combrinck, C. (2018). Dialects matter: The influence of dialects and code-switching on the literacy and numeracy achievements of isiXhosa Grade 1 learners in the Western Cape. *Journal of Education (University of KwaZulu-Natal)*, (72), 21-37. https://doi.org/10.17159/2520-9868/i72a02

Mubaiwa, D. (2020). Partnerships in Building a Culture of Reading in South Africa: The case of Nal'ibali. *Mousaion*, *38*(3). https://doi.org/10.25159/2663-659x/7987

Muchuchuti, N. (2015). The Influence of Parental Involvement on the Learning outcomes of their Children: A Case study of Primary School Children in Matabeleland Regions.

IOSR Journal of Research & Method in Education, 5(6), 25-32. https://www.tandfonline.com/toc/cwse20/current

Muir, T. (2012). Numeracy at home: Involving parents in mathematics education. *International Journal for Mathematics Teaching and Learning*, (2012), 1-13. https://www.cimt.org.uk/ijmtl/index.php/IJMTL

Mullis, I. V., & Martin, M. O. (2008). *Overview of TIMSS 2007.* TIMSS & PIRLS. https://timssandpirls.bc.edu/timss2007/PDF/T07_TR_Chapter1.pdf

Mullis, I. V. S. & Martin, M. O. (2013). *TIMSS 2015 Assessment Frameworks*. TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mullis, I. V. S., Martin, M. O. & Loveless, T. (2016). *20 years of TIMSS - International Trends in Mathematics and Science Achievement, Curriculum, and Instruction*. TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 International Results in Mathematics*. http://timssandpirls.bc.edu/timss2015/international-results/

Munje, P. N. & Mncube, V. (2018). The lack of parent involvement as hindrance in selected public primary schools in South Africa: the voices of educators. *Perspectives in Education, 36(1), 80-93.* https://doi.org/10.18820/2519593x/pie.v36i1.6

Mutekwe, E. (2014). Manifestations of Differential Cultural Capital in a University Classroom: Views from Classroom Observations and Focus Group Discussions in a South African University. *Journal of Education and Learning*, *8*(4), 349-362. https://core.ac.uk/download/pdf/208041338.pdf

Mutodi, P., & Ngirande, H. (2014). The Impact of Parental Involvement on Student Performance: A case Study of a South African Secondary School. *Mediterranean Journal of Social Sciences, 5(8).* https://doi.org/10.5901/mjss.2014.v5n8p279

Myers, T. A. (2011). Goodbye, listwise deletion: presenting hot deck imputation as an easy and effective tool for handling missing data. *Communication Methods and Measures*, *5*(4), 297–310. https://doi.org/10.1080/19312458.2011.624490

Neuschmidt, O. (2019). *Using TIMSS 2015 data to compare educational effectiveness-enhancing factors in the countries of the Gulf Cooperation Council (GCC*). (Doctoral dissertation). University of Harmburg, Harmburg, Germany. https://www.academia.edu/40406820/Using_TIMSS_2015_data_to_compare_educational_effectiveness_enhancing_factors_in_the_countries_of_the_Gulf_Cooperation_Council_GCC_

Newman, D. A. (2014). Missing data: five practical guidelines. *Organizational Research Methods*, *17*(4), 372–411. https://doi.org/10.1177/1094428114548590

Niklas, F., & Schneider, W. (2014). Casting the die before the die is cast: The importance of the home numeracy environment for preschool children. *European Journal of Psychology of Education*, *29*(3), 327-345. https://doi.org/10.1007/s10212-013-0201-6

Nilsen, T., Gustafsson, J. E., & Blömeke, S. (2016). Conceptual framework and methodology of this report. In T. Nilsen, J-E. Gustafsson (Ed.), *Teacher quality, instructional quality and student outcomes* (pp. 1-19). Springer.

Núñez, J. C., Suárez, N., Rosário, P., Vallejo, G., Valle, A., & Epstein, J. L. (2015). Relationships between perceived parental involvement in homework, student homework behaviors, and academic achievement: Differences among elementary, junior high, and high school students. *Metacognition and Learning*, *10,* 375–406. https://doi.org/10.1007/s11409-015-9135-5

Ogbonnaya, U. I., & Awuah, F. K. (2019). Quintile ranking of schools in South Africa and learners' achievement in probability. *Statistics Education Research Journal, 18*(1), 106–19. https://doi.org/10.52041/serj.v18i1.153

Ólafsson, R.F., Grønmo, L.S., Gustafsson, J.-E., Björnsson, J.K., Kupari, P., Mejding, J.,Nissinen, K., Rønberg, L., Rosén, M., Sulkunen, S. & Hansen, K.Y. (2014). *Northern Lights on TIMSS and PIRLS 2011: Differences and similarities in the Nordic countries.* Nordic Council of Ministers.

Pandey, K. (2014). Objectivity in Social Sciences. *Political Science.* https://doi.org/10.2139/SSRN.2399299

Panhwar, A. H., Ansari, S., & Shah, A. A. (2017). Post-positivism: an effective paradigm for social and educational research. *International Research Journal of Arts & Humanities, 45*(45). https://sujo-old.usindh.edu.pk/index.php/IRJAH/article/download/3371/2447

Perera, L. D. H., Bomhoff, E.J & Lee, G. H. Y. (2014). Parents' attitudes towards science and their children's science achievement. *International Journal of Science Education*, 36(18), 3021–3041. https://doi.org/10.1080/09500693.2014.949900.

Peters, M., Seeds, K., Goldstein, A., & Coleman, N. (2008). *Parental involvement in children's education 2007* (Research Report DCSF-RR034). Department for Children, Schools and Families.

Prinsloo, C. H., Rogers, S. C., & Harvey, J. C. (2018). The impact of language factors on learner achievement in Science. *South African Journal of Education*, *38*(1). https://sujo-old.usindh.edu.pk/index.php/IRJAH/article/download/3371/2447

Pritchard, R. (2004). *Investigating parental attitudes and beliefs in mathematics education.* http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.529.8171

Rahman, M. S. (2017). The advantages and disadvantages of using qualitative and quantitative approaches and methods in language "Testing and Assessment" Research: A Literature Review. *Journal of Education and Learning*, *6*(1), 102-112. http://hdl.handle.net/10026.1/16598

Ramirez G., Gunderson E. A., Levine S. C., & Beilock S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development. 14, 187–202*. https://doi.org/ 10.1080/15248372.2012.664593. https://doi.org/10.1080/15248372.2012.664593

Ramohapi, S., Maimane, J. R., & Rankhumise, M. P. (2015). Investigating factors contributing to learner performance in mathematics: A case study of some selected schools in Motheo District. *International Journal of Educational Sciences*, *8*(3), 445-451. https://doi.org/10.31901/24566322.2015/08.03.02

Reddy, V., & Hannan, S. (2018). TIMSS in South Africa: Making global research locally meaningful. *Human Sciences Research Council*. http://www.hsrc.ac.za/en/review/hsrc-review-april-june-2018/timss-in-sa.

Reddy, V., Isdale, K., Juan, A., Visser, M., Winnnaar, I., & Arends, F. (2016). TIMSS 2015: Highlights of Mathematics Achievement amongst Grade 5 South African Learners. *Human Sciences Research Council*, 1-16.

Reddy, V., Prinsloo, C., Arends, F., Visser, M., Winnaar, L., Feza, N., . . . Maja, M. (2013). *Highlights from TIMSS 2011. The South African perspective.* Human Sciences Research Council Press.

Reddy, V., Zuze, T. L., Visser, M., Winnaar, L., Juan, A., Prinsloo, C. H., & Rogers, S. (2015). *Beyond benchmarks*. *What twenty years of TIMSS data tell us about South African* Education. Human Sciences Research Council Press.

Ridley, J. (2017). Nanny to the supper-rich tells all. *New York Times.* https://nypost.com/2017/05/03/a-real-life-mary-poppins-shares-her-horror-stories/

Robinson, K., & Harris, A. (2014). *The broken compass: Parental involvement with children's education*. Harvard University Press.

Rowan-Kenyon, H. T., Swan, A. K., & Creager, M. F. (2012). Social cognitive factors, support, and engagement: Early adolescents' math interests as precursors to choice of career. *The Career Development Quarterly, 60(1),2–15*. https://doi.org/10.1002/j.2161-0045.2012.00001.x

Sapungan, G. M. & Sapungan, R. M. (2014). Parental Involvement in Child's Education: Importance, Barriers and Benefits. *Asian Journal of Management Sciences and Education*, 3(2), 42-48. http://ajmse.leena-luna.co.jp/

Schoeman, R. (2018). *The role of CAPS in preparing school learners for responsible leadership: An exploration of learner experiences at three high schools in the Western Cape*. (Doctoral thesis). University of Stellenbosch

Segers, E.,Kleemans, T., & Verhoeven, L. (2015). Role of Parent Literacy and Numeracy Expectations and Activities in Predicting Early Numeracy Skills. *Mathematical Thinking and Learning*, 17(2-3), 219-236. https://doi.org/10.1080/10986065.2015.1016819

Singh, M (2016). Relationship between Academic Achievement and Parental Encouragement. *International Journal of Engineering Science and Computing*, *6*(4), 3695-3698. https://ijesc.org/

Silinskas, G., & Kikas, E. (2019). Parental Involvement in Math Homework: Links to Children's Performance and Motivation. *Scandinavian Journal of Educational Research*, 63 (1), 17-37. https://doi.org/10.1080/00313831.2017.1324901

Smith, M. C. (2011). Which in-and out-of-school factors explain variations in learning across different socio-economic groups? Findings from South Africa. *Comparative Education*, *47*(1), 79-102. https://doi.org/10.1080/03050068.2011.541678

Soni, A., & Kumari, S. (2015). The role of parental math attitude in their children math achievement. *International Journal of Applied Sociology 2015, 5(4), 159-163.* http://www.sapub.org/journal/aimsandscope.aspx?journalid=1116#:~:text=International%20Journal%20of%20Applied%20Sociology%20is%20a%20peer%2Dreviewed%20international,from%20all%20over%20the%20world.

Sonnenschein, S., Baker, L., Serpell, R., Scher, D., Truitt, V. G., & Munsterman, K. (1997). Parental beliefs about ways to help children learn to read: The impact of an entertainment or a skills perspective. *Early Child Development and Care*, *127*(1), 111-118. https://www.tandfonline.com/toc/gecd20/current

Spaull, N. (2013). South African Education in South Africa: The quality of education in South Africa 1994-2011, *Centre for Development and Enterprise.*

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. https://doi.org/10.1016/j.ijedudev.2015.01.002

Spillane, J. Hallet, T. & Diamond, J. (2008). Forms of capital and the construction of leadership. *Schools and Society: A Sociological Approach to Education*, 96. https://uk.sagepub.com/en-gb/afr/schools-and-society/book249437

Statistics South Africa (2017) *General Household Survey 2016.* Stats SA.

Subedi, K.R. (2018). Shadow Education: A Role of Private Tutoring in Learning. *International Journal of Humanities and Social Sciences*, 1(2). https://files.eric.ed.gov/fulltext/ED591992.pdf

Shay, S. (2020). *A key subject signals South Africa's latest test results isn't to be celebrated.* The conversation. https://www.studyinternational.com/news/south-africa-matric-results-2019

Tan, C. Y. (2017). Examining cultural capital and student achievement: Results of a meta-analytic review. *Alberta Journal of Educational Research, 63(2), 139-159*. https://journalhosting.ucalgary.ca/index.php/ajer/

Tan, C. Y., Peng, B., & Lyu, M. (2019). What Types of Cultural Capital Benefit Students' Academic Achievement at Different Educational Stages? Interrogating the Meta-analytic Evidence. Educational Research Review, 28, 100289. https://doi.org/10.1016/j.edurev.2019.100289

Taylor, S., & von Fintel, M. (2016). Estimating the impact of language of instruction in South African primary schools: A fixed effects approach. *Economics of Education Review*, *50*, 75-89. https://doi.org/10.1016/j.econedurev.2016.01.003

Uscianowski, C. (2018). How Parents Support Early Numeracy Development During Shared Math Storybook Reading. (PhD thesis). Columbia university. USA.

Van der Berg, S. (2008). Poverty and education. *Education policy series*, *10*, 28.

Van der Berg, S. & Gustafsson, M. (2017). *Quality of Basic Education. A Report to Working Group 1 of the High Level Panel on the Assessment of Key Legislation*. Unpublished. Stellenbosch.

Van der Berg, S., Spaull, N., Wills, G., Gustafsson, M., & Kotzé, J. (2016). Identifying binding constraints in education. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.2906945

Van der Berg, S., Taylor, S., Gustafsson, M., Spaull, N., & Armstrong, P. (2011). Improving education quality in South Africa. *Report for the National Planning Commission*, *2*, 1-23. https://resep.sun.ac.za/wp-content/uploads/2012/10/2011-Report-for-NPC.pdf

Visser, M., Juan, A. & Feza, N. (2015). Home and school resources as predictors of mathematics performance in South Africa, *South African Journal of Education, 35(1), 1-10.* https://doi.org/10.15700/201503062354

Weerasinghe, D. (2016a). A mixed methods design to investigate student outcomes based on parental attitudes, beliefs, and expectations in mathematics education. https://www.researchgate.net/figure/Detailed-explanatory-sequential-mixed-methods-design_fig3_306424427

Weerasinghe, D. (2016b). Parental expectations and student performance in secondary school mathematics education. *International Journal of Social, Behavioural, Educational, Economic, Business and Industrial Engineering, 10*(1), 106–111. https://publons.com/journal/73159/international-journal-of-social-behavioral-educati/

Weerasinghe, D. (2019). A Cross-Cultural Study of Parents' Perceptions and Involvement in their Children's Mathematics Homework. Proceedings at the *International Conference on Social Sciences and Management. Beijing, China. 18-21 June, 2019.*

Williams, T. A., Sweeney, D. J., & Anderson, D. R. (2012). *Contemporary business statistics* (4th ed.). South-Western.

Wills, I.R. (2011). *The history of Bantu education: 1948-1994*. (Doctoral thesis). Catholic University. https://doi.org/10.4226/66/5a61e25c686a

Yamamoto, Y. & Holloway, S. (2010). Parental Expectations and Children's Academic Performance in Sociocultural Context. *Education Psychological Review*, *22*(3), 189-214. https://doi.org/10.1007/s10648-010-9121-z

Yin, L. & Fishbein (2020). Creating and Interpreting the TIMSS 2019 Context Questionnaire Scales. In Martin, M. O., von Davier, M. & Mullis, I. V. S. (Eds.). (2020) *Methods and Procedures: TIMSS 2019 Technical Report.* Boston, USA: TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2019/methods

Yong, A. G., & Pearce, S. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in Quantitative Methods for Psychology*, *9*(2), 79-94. https://doi.org/10.20982/tqmp.09.2.p079

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Watkins, M. W. (2018). Exploratory factor analysis: A guide to best practice. *Journal of Black Psychology*, *44*(3), 219-246. https://journals.sagepub.com/doi/10.1177/0095798418771807.