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A Multilevel Analysis of Learner and School Contextual Factors associated with Educational Quality

A thesis submitted in fulfilment of the requirements for the degree

of Magister Philosophiae

By

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Table of Contents

List of Figures

List of Tables

List of Acronyms

ANOVA	Analysis of Variance
DBE	Department of Basic Education
ECOSOC	Economic and Social Council *(United Nations)*
EFA	Education for All
FET	Further Education and Training
HLM	Hierarchical Linear Modelling
ICT	Information and Communication Technology
IDB	Analyser International Data Base Analyser
IEA	International Association for the Evaluation of Educational Achievement
IRT	Item Response Theory
ISCED	International Standard Classification of Education
LoLT	Language of Learning and Teaching
MDG	Millennium Development Goals
NER	Net Enrolment Rate
OLS	Ordinary Least Squares
PIRLS	Progress in Reading Literacy Study
PPS	Probability Proportional to Size
SACMEQ	Southern and East African Consortium for Monitoring Educational Quality
SES	Socio-Economic Status
SPSS	Statistical Package for the Social Sciences
TIMSS	Trends in International Mathematics and Science Study
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNICEF	United Nations Children's Fund (formerly United Nations International Children's Emergency Fund)

Declaration

I hereby declare that this thesis and the work reported herein was composed by and originated entirely from me. Information derived from the published and unpublished work of others has been acknowledged in the text and references are given in the list of sources.

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Abstract

The South African schools act, (number 5, 1996), asserts that all learners have a right to access both basic and quality education without discrimination of any sort. Since the implementation of the Millennium Development Goals there has been a drive by the Department of Education to ensure that all learners have access to basic education by 2015. However what remains a challenge after almost 20 years of democracy is the poor quality of education and this is clear from the results of international assessment studies. Results from studies like the Trends in International Mathematics and Science Study and Southern and East Africa Consortium for Monitoring Educational Quality, show that South African children perform well below international averages. In this study learner Mathematics achievement scores taken from the Trends in International Mathematics and Science Study 2011 cycle will serve as a proxy for educational quality. Using multilevel analysis the current study aims to use a 2-level Hierarchical Linear Model to firstly; determine the learner and family background factors associated with education quality. Secondly; factors at the school level will be identified and proven to be associated with education quality. Variables selected for the study was based on Creamer's theory of school effectiveness which looked at school, classroom level inputs as well as learner background variables to explain student level achievement. The results show that at the learner's level the most significant factors were the age of the leaner, in the sense that grade age appropriate learners obtained higher scores than overage learners. Learner's perception of mathematics is extremely important and has a positive effect on mathematics performance. In the current study mathematics perception refers to learners valuing and liking mathematics as well learner confidence in learning mathematics. Learners who said they were bullied as school generally scored lower than learners who were not bullied. At the school level the most significant factors were teacher working conditions, teachers' specialisation in mathematics, school socio-economic status, and general infrastructure. Interesting to note at the school level is when socio-economic status was included in the model as a single variable the score difference between low socio-economic status and high socio-economic status

schools was almost 46 points. However when the factors mentioned above were added to the model the difference in scores dropped by almost half.

Key Words:

Learner background factors, education quality, TIMSS, hierarchical linear modelling, Millennium Development Goals, mathematics performance, Education For All, multilevel analysis, school effectiveness, variance explained

Chapter 1

1 Introduction

The purpose of this study is to determine which learner background and school factors are associated with educational quality where Mathematics scores from the Trends in International Mathematics and Science Study (TIMSS) 2011 are used as a proxy for educational quality. This chapter provides the background to the research problem as well as an introductory review of the literature.

The Department of Education recognises that South Africa's schooling system performs below its potential (Motshekga, 2010). Even though great strides have been taken by the Government to improve access to schools, the challenge that still exists after almost twenty years of democracy is to improve the quality of education. In an attempt to monitor improvements or changes in educational quality, the Department of Basic Education (DBE) has initiated standardised international testing programmes within schools. Testing programs like the Trends in International Maths and Science Study (TIMSS), the Progress in International Reading Literacy Study (PIRLS) and the Southern and East Africa Consortium for Monitoring Educational Quality (SACMEQ) are used to monitor improvements in learner performance which will serve as an indicator of educational quality.

The results of TIMSS between 1995 and 2003 showed no significant improvement in the average Mathematics performance (Reddy, 2012); however, there appears to be a significant improvement between the 2003 and 2011 cycles. This significant improvement could be due to policies and curriculum changes implemented by the Government after 1994 in an attempt to rectify the inequality between schools as a result of the legacy of apartheid. It is important to note that the average improvement witnessed in 2011 is, however, still below the international centre point of 500, implying that South Africa still has to improve the quality of education provided to learners so that scores in studies like TIMSS can improve beyond the centre point. The improvement witnessed in the 2011 TIMSS results shows that the initiatives implemented by the Government has had positive outcomes; however, there is still a long way to go to ensure that quality improves.

Sanders and Epstein (2005) stated that educational quality in schools can only be attained when connections are made between the home, the school and the community. Learners' school and home situations affect their chances of academic success and of educational quality improvement (Ma & Klinger, 2000).

1.1 Rationale/Background

In September 2000 the Millennium Declaration was adopted and approved by more than 160 countries across the world. The output of this declaration was that eight goals were set to be achieved by 2015. These goals are measurable and are referred to as the Millennium Development Goals (MDGs). Commitments were made by all countries to decrease poverty and hunger and to provide access to clean water, thus reducing ill-health. In addition countries had to ensure that all children had access to a quality education regardless of their gender (United Nations, 2000).

According to the South Africa MDG 2010 Country Report great strides in reducing inequalities caused by the apartheid era have been made in ensuring that all children aged between 7 and 15 complete compulsory schooling (Grade 1 to Grade 9) as stated in the *South African Schools Act 5 1996* which was amended in 2006 (South Africa. Dept. of Education, 2006). To assess the extent of achievement of this MDG, school access is measured by using the net enrolment rate (NER). Between 1996 and 2009 the primary NER for children aged 7-13 has increased from 88% to 98%. It therefore seems that South Africa will reach the intended goal by 2015.

The dramatic increase in the number of learners entering the system has placed significant strain on the existing education system. The rate at which learners are entering the system is not equal to the rate at which schools are provided with human and physical resources; hence teacher-pupil ratios are high.

Since the inception of the education MDG, attention in developing countries has been focused on enrolment rates and ensuring that these rates improve significantly in order to meet the MDG. Another education framework that was accepted around the time of the MDG was that of Education for All (EFA). It contains six goals of which the last goal focuses on improving the quality education provided to learners. However, research done in South Africa has shown that learners at Grade 6 level are unable to read or do basic Mathematics (Hewlett Foundation, 2008). It has thus become clear that access to schools is not sufficient to ensure a decent level of basic learning and that quantity and quality should not be treated as two independent terms.

Quality is suffering because millions of learners are entering schools but too few are learning. Research has shown that only 45.2% of Grade 1 learners reach Grade 12 with more than 50% having dropped out before Grade 12. Of the Grade 12 learners who sit to write an examination, only 26.6% obtain exemption and hence are eligible for university entrance (Scherer, 2013). This is a clear indication of the calibre of matriculants the country is producing and indirectly reflects the quality of education received by these learners.

Learner achievement or outcomes are generally used as a proxy for educational quality (Evertson, Hawley, & Zlotnik, 1985; Frempong, Reddy, & Kanjee, 2011) with a multitude of factors influencing learner outcomes, including home environment, family support, society and school playing a role in learner outcomes (Coleman, 1988; Ma & Klinger, 2000; Uwaifo, 2008).

Children in any society are investments, and the more positive the influences received from parents, societies and communities, the greater the returns on the investments will be (Anderson, 2003).

The structure of data from social organisations such as schools, families and communities is multilevel in nature, and this study uses multilevel analysis to arrive at its conclusions. Raudenbush and Willms stated that the multilevel approach enables researchers to test complicated theories about educational processes that involve interaction between variables at different levels of the education system (Raudenbush & Willms, 1995). Burstein notes that education occurs in some type of group context and that the educational exposure that learners receive occurs in the groups to which they belong (Burstein, 1980). Learners from a particular classroom come from communities that are likely to be homogeneous in terms of family background, and socio-economic status and race, for example. Furthermore, they share the experience of being with the same teacher or teachers, and the physical environment may lead to homogeneity over time.

Traditional statistical methods like analysis of variance (ANOVA) and ordinary least squares (OLS) do not take the multilevel nature of educational data into account and when used lend themselves to statistical difficulties like deciding what unit of analysis to use, for example, the learner or the school (Lee, 2000). Statistical errors that are also encountered are aggregation bias, incorrectly estimated standard errors and heterogeneity of regression (Lee, 2000). Multilevel modelling is an extension of multiple regression. However, regression produces a single equation and does not incorporate school differences. Multilevel analysis, on the other hand, takes school differences into account and respects the heterogeneity of social data structures (Paterson & Goldstein, 1991) .

Not much multilevel analysis has been done in the field of education in South Africa and in fact only seven articles have been found to explain factors affecting performance. The data used in these articles was obtained mostly from the Southern and East Africa Consortium for Monitoring Educational Quality SACMEQ (2000/2001); one article used the TIMSS 1998/1999 data and another used Grade 6 Systemic data obtained in 2004. The current study seeks to apply the Hierarchical Linear Modelling (HLM) methodology using very recent data to explain the factors in both the home and the school that affect educational quality.

1.1.1 Educational quality

While South Africa is on track to meet the MDG of universal education, it would seem that access has been fast-tracked at the expense of the quality of education received by learners. In an attempt to provide clarity on the concept of educational quality it is important to define what it is. Research shows that the definition is not straightforward and providing a few definitions would perhaps aid in understanding what educational quality is:

A good quality education is one that enables all learners to realise the capabilities they require to become economically productive, develop sustainable livelihoods, contribute to peaceful and democratic societies and enhance wellbeing. The learning outcomes that are required vary according to context but at the end of the basic education cycle must include threshold levels of literacy and numeracy and life skills including awareness and prevents disease (Tikly, 2010, p.13)

The United Nations Children's Fund (UNICEF) in 2000 described education quality as a complex system embedded in a political, cultural and economic context where these contexts influence each other sometimes.

Howie (2011) states that characteristics of a high performing, quality school are that the school is in a safe environment, has the minimum required level of resources, has dedicated and knowledgeable leadership and teachers and finally has good community support.

Educational quality is also defined as the extent to which learners effectively advance through the education system and exit with appropriate scores. The inability of a learner to progress through the system successfully has dire consequences for the learner as well as the education system (UNESCO, 2004). This would result in grade repetition which is currently a dilemma faced by the country (UNESCO, 2004). Research has shown that learners who are overage obtain scores that are significantly lower than grade-age appropriate learners (Kunje, Selemani-Meke, & Ogawa, 2009).

The basic dimensions of educational quality are firstly inputs, which refer to instructional infrastructure and learner-teacher ratios. Secondly, processes, which refer to issues like time on task, teacher preparation and teaching practices. The third dimension is outputs which refer directly to learner scores; the last dimension is outcomes, which in this case refer to pathways followed after completion of secondary education.

Many researchers have attempted to determine a single measure of educational quality; where some regard it as "the perceived quality of services rendered" others use educational engagement to define educational quality. There is, however, a great majority that use learner achievement or test scores as measurement of educational quality (Card & Krueger, 1992; Michaelowa, 2001).

1.1.2 Factors affecting educational quality

Research has shown that schools are only one of the factors that influence the development of children and youth (Huitt, 1999; Ryan & Adams, 1995). Goddard (2003), states that the personal characteristics of learners influence their academic success. When the contexts of school, home and community work together it has been shown to improve learners' school-related attitudes (Sanders & Epstein, 2005). For learners to succeed in school and in life communication and exchange between school, family and community groups need to be improved (Huitt, 1999).

Educational success can be viewed as a holistic entity that involves the school, family and community, neither of which can operate individually. Research has shown that factors in the family as well as factors in the school can have a positive or negative effect on the education of the child (Frempong et al., 2011; Ma & Klinger, 2000). Family factors may include issues of parental involvement in the schooling of the child, the family structure, the learner's perception of school climate and attitude towards Mathematics. School factors can be sub-divided into school climate and school context where school climate refers to teacher satisfaction, leadership and disciplinary climate; school context on the other hand speaks to class size, location of the school and the average socio-economic status of the school.

1.2 Theoretical framework

A number of models have been considered for the theoretical framework of the current study in an attempt to model the factors that are associated with educational quality. Four theories were considered, namely Maslow's hierarchy of needs theory, James Coleman's theory of social capital, Ryan and Adam's family-school relationship model and finally Creemers's theory of school effectiveness. In Chapter 2 these theories will be explored in detail and will be demonstrated why Creemers's theory of school effectiveness was selected.

1.3 Aims

Since the study is multilevel in nature the aims are listed as they pertain to each level of the analysis.

At the learner level the aim is to determine the association between learner contextual factors and learners' Mathematics performance. Mathematics scores form a proxy of educational quality. Learner background variables selected at this level are the following:

- Learner age;
- Family structure;
- Parental involvement in learners' schooling;
- Family socio-economic status;
- Home language versus language of TIMSS tests administered;
- Population group;
- Learners being bullied;
- Learner perception of school climate;
- Educational resources in the home;
- Learners who say they like Mathematics;
- Learners who say they value Mathematics;
- Learners who say they are confident when doing Mathematics.

At the school level the aim is to determine the school factors that are associated with educational quality. The following factors are considered:

- How often assessment tests are administered to learners;
- School infrastructure;
- Class size;

- School socio-economic status (SES);
- Teachers' perception of school climate;
- Number of years teaching experience;
- Teacher qualifications;
- Mathematics as major area of study;
- Resource shortages;
- Teacher working conditions.

1.4 The research problem

The focus of the current study is on the quality of education received by learners in schools. The improvement of the quality of education received by learners should not depend solely on the school but on the teachers, the family and the community as well. As previously stated the child, the teacher, the family and the community (the school) have influences on learner performance and hence should work together in an attempt to assist the learner to succeed academically. The research problem then is to determine the learner contextual factors as well as the school contextual factors that are associated with the learners' Mathematics performance and in turn educational quality.

1.5 Research design and methodology

This study has been utilising secondary data from the Trends in International Mathematics and Science Study (TIMSS) that was conducted in August/September 2011 and has been released into the public domain and can be accessed from the URL http://timssandpirls.bc.edu/timss2011/international-database.html. Learner Mathematics assessment tests were administered to the learners in both Mathematics and Science. In addition to the assessment tests contextual questionnaires were also administered to learners, to the TIMSS Mathematics and Science teachers as well as to the principal of the sampled schools to obtain information that would assist in explaining instruction and learning in Mathematics and Science.

TIMSS is a trend study and is administered every four years, the first year being in 1995; hence with the accumulation of items/test questions since 1995 it would be impossible for all items to be administered to all learners in a 90 minute testing session. For this reason TIMSS follows a matrix sampling design where items are divided into blocks and rotated among the learners. This means that not all learners would have a complete score; Item Response Theory is used to estimate a learner's score and creates five plausible values or estimates. In this study the five mathematics plausible values will serve as the dependent variable and the independent variables were selected from the learner, the teacher and the school questionnaires and are used to determine if significant relationships exist.

1.6 Data analysis

Descriptive statistics such as frequencies were employed in a software package called Statistical Package of Social Sciences (SPSS) to describe the spread of the different variables (Field, 2009). Graphical representations such as histograms were used to assess the distribution of the continuous dependent variable, as well as the continuous independent variables. Simple bivariate analysis was performed to determine if significant relationships exist between the continuous dependent and the individual independent variables. In the case of categorical independent variables an ANOVA was used to test for differences and the Bonferroni test was used to determine specific group differences. Correlations were used to test for associations between the continuous independent variables and the dependent variable.

In certain cases variables/questions in the questionnaires referring to the same construct were combined to create measures/indices to assist with the analysis. The TIMSS international study centre provides a few such measures that are discussed in Chapter 3.

Hierarchical linear modelling (HLM) is commonly used in educational research due to the nested nature of educational data. Generally learners are nested within schools; schools are nested within districts, and districts with a province. A two-level hierarchical linear model (HLM) was used with learner data at level 1 and school/teacher data at level 2. The five plausible values created by TIMSS for each learner were imported into HLM and serve as the dependent variables. Five models were created with every run in HLM, one for every plausible value; hence six sets of output were produced: one for each plausible value, the sixth one being the average across the five sets of output. The sixth output file was then used to read the output from as it is the average of the five plausible value outputs.

1.7 Structure of the dissertation

Chapter 2 provides a review of the literature pertaining to learner contextual factors and school contextual factors and their impact on educational quality.

Chapter 3 defines the research problem, the aims of the study and the hypotheses. Reference is made to the sampling frame used and details of how the sample was selected are provided. Data analysis techniques are discussed based on the quantitative nature of the study.

Chapter 4 presents the findings from the descriptive analysis performed as well as the results of the HML analysis.

The conclusions based on the results are discussed in Chapter 5 and compared to the literature. Appropriate recommendations conclude the thesis.

Chapter 2

2 Literature Review

This chapter will provide a review of selected theoretical frameworks as well as the factors that are known to be associated with education quality. When looking at school factors the study focuses on school effectiveness research and uses multilevel analysis to select significant contextual factors that affect learner performance (educational quality), which is controlled to determine the school level factors associated with school effectiveness.

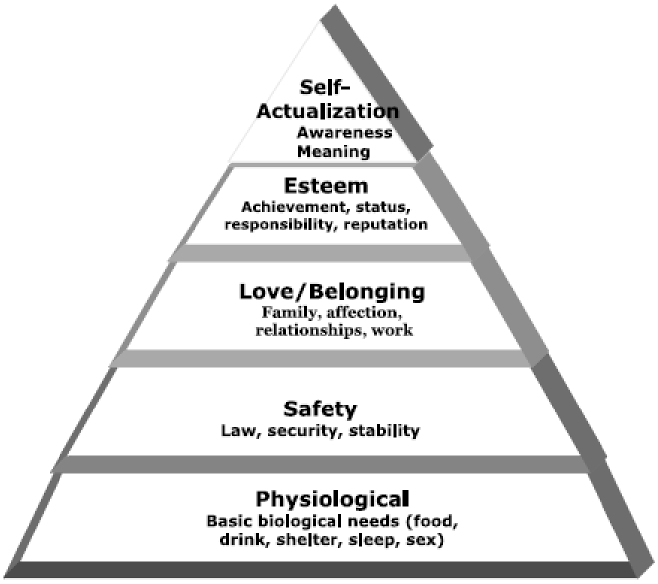
2.1 Theoretical framework

The focus of the study is learners, teachers and schools and how these three together affect the quality of education. A number of theories have been developed that can be used to explain how contextual factors relating to learners, their families and schools have an impact on learner performance and in turn on the quality of education. Theories discussed in this section include Maslow's theory of the hierarchy of needs (1954); James Coleman's theory of social capital (1988), Ryan and Adams's family-school relationships model of parental influences on school success (1995) and Creemers's theory of school effectiveness (1994).

2.1.1 Maslow's theory of the hierarchy of needs (1954)

Abraham Maslow posited that human behaviour is strongly linked to human needs, and hence he developed his model of the hierarchy of needs (Chung, 1969). This is divided into basic or deficiency needs, and growth needs. The hierarchy referred to is represented as a prism, with basic needs at the base of the prism and growth needs at the peak. There are five levels in the prism with the bottom three (the basic needs) being physiological needs, safety needs and belongingness. Once these "basic" needs have been met, only then does one move to the fourth and fifth levels that are esteem and self-actualisation needs. Maslow believed that everyone has a desire to reach self-actualisation or the desire for fulfilment (Koltko-Rivera, 2006; McLeod, 2007) and that failure to progress to the upper levels in the hierarchy occurs when basic needs are not met (see Figure 2.1).

Figure 2.1: Maslow's theory of human motivation (Zalenski & Raspa, 2006, p. 1121)



Physiological needs are taken as the starting point for motivational theory and refer to basic needs like air, food and water. Safety and security needs are at the next level in the hierarchy and can only be met once the basic survival needs have been met. Needs here are personal and financial safety, health and well-being (McLeod, 2007). The need to belong follows that of safety in the hierarchy and includes factors like friendship, intimacy and family. Maslow says that humans need to have a sense of belonging and acceptance from, for example, family, teachers and co-workers, otherwise they will be prone to loneliness and social anxiety. The second last level is that of esteem needs and can be divided into two areas: the desire for strength, achievement and confidence, and for prestige and recognition from others. The final level is the need for self-actualisation or self-fulfilment.

In terms of education Maslow's opinion is that no learning will take place unless the basic needs of a child have been met. Learners need to feel safe and that they belong, and have to be nourished before motivation to learn will take place. Self-actualisation manifests only once the basic needs have been met and self-esteem has been developed. One limitation to Maslow's theory is the methodology used to determine the factors to describe self-actualisation. He used a qualitative method called biographical analysis to study 21 individuals that he identified as having achieved self-actualisation. This method is not representative of humanity in general and hence the theory is relevant to the individuals he interviewed only. In addition (McLeod, 2007) argues that from a scientific perspective Maslow's approach is problematic because biographical analysis is subjective and based on the researcher's opinion and is hence prone to bias which in turn reduces the validity of the data.

Although Maslow states that if people's basic needs are not met they are incapable of meeting higher order needs, this is not necessarily the case in countries like South Africa where a large proportion of the population lives in poverty but are still capable of meeting higher order needs like love and belongingness. Moreover, looking at the education system as well as the poverty levels in South Africa, it is possible and highly likely that children living in complete poverty can succeed in their schooling career with the right motivation from parents, the community and teachers.

For these reasons Maslow's theory was not used in this current study. In the following section James Coleman's theory of social capital (1988) is examined and its relevance to this study considered.

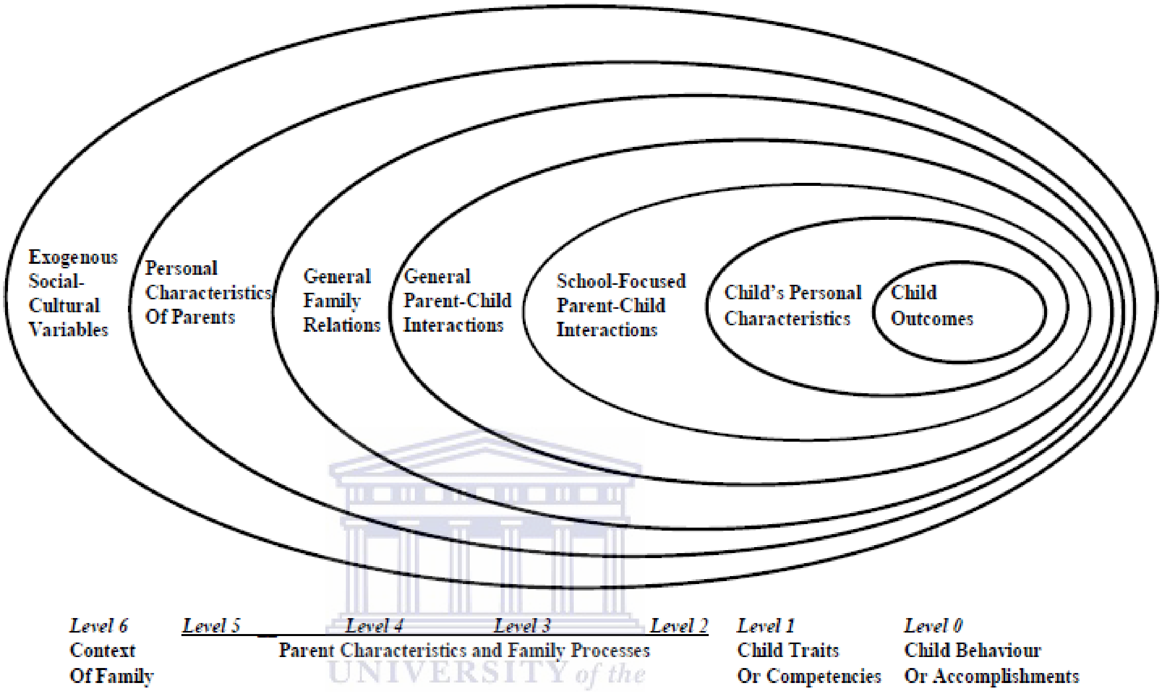
2.1.2 James Coleman's theory of social capital

Coleman uses "social capital" to explain how family background and school relationships affect learning outcomes at school and the social resources available to aid educational growth. He postulates that family background cannot be analysed as a single entity but rather that it should be analytically divided into three components, namely financial capital, human capital and social capital. Financial capital refers to the families' wealth and ability to avail themselves of physical resources to aid the child's educational growth. Capital resources refer to things like a study desk where homework is done, materials to support learning and financial resources for paying school fees. Human capital, on the other hand, refers to parental education that indirectly affect the child's learning by providing an intellectual environment to aid learning. Social capital refers to parental involvement (time spent) in assisting with homework, creating an enabling environment for children to learn. In a nut shell social capital is the relation between parents and children. More specifically, social capital relates to adult involvement, which could be parents, grandparents, aunts or uncles who reside with children and are actively involved in the lives of these children. Coleman says that human or financial capital, if not combined with social capital, is worthless. Hence having a parent with high qualifications and plenty of educational resources in the home is worthless unless it is used to communicate with children in an attempt to extend knowledge. Coleman states that “Social capital within the family that gives the child access to the adult’s human capital depends both on the physical presence of adults in the family and on the attention given by adults to the child” (Coleman, 1988). Coleman believes that the family is the most important factor in explaining learner performance; however, subsequent research has found that schools play an important role in the academic success of learners. For this reason Coleman was not used in the current study.

2.1.3 Ryan and Adam’s family-school relationship model

The family-school relationship model was developed by Ryan and Adams in 1995 (Ryan & Adams, 1995) and includes all the family characteristics and processes that may affect learner performance. It consists of seven levels and is structured on a proximal-distal dimension. The interaction of variables on the proximal-distal dimension is said to be bidirectional where the interaction strength is greater between adjacent levels. Level-0 is also referred to as the target of interest, which generally refers to learner performance. Level-1 is the learner’s personal characteristics, which are variables or constructs that occur in the family and that have an indirect effect on learner achievement. Variables to consider at this level are family crises that the learner is exposed to and the family’s socio-economic status. Level-2 is school-focused parent-child interactions and refers to issues like parental involvement in school matters like homework but excludes involvement in activities at the school, like social events and meetings. Level-3 is referred to as the general-parent child interactions which would be parental discipline and parenting styles. Level-4 encompasses general family relations that refer to how the family is presented as a group entity. Level-5 relates to variables that refer to the personal characteristics of the parents, such as personality and possibly psychiatric disorders. Level-6 is exogenous social and biological variables that are information like family socio-economic structure, marital status of the parents and family structure (See Figure 2.2).

Figure 2.2: Ryan and Adams' Family-School Relationship model (Ryan & Adams, 1995, p. 6)



Considering the multilevel nature of educational data and the fact that the current study deals with learner and school factors, the family-school relationship model is not appropriate for the entire study but only for the learner contextual factors and their association with performance. This model, however, does not work for school level factors because the model as formulated by Ryan and Adams focuses on processes within the family and is not meant to determine factors in the school environment that affect learner achievement (educational quality).

The fourth model considered is that which was used by the TIMSS international study centre since the inception of TIMSS in 1995. For purposes of this study the model of school effects is used as the theoretical framework.

2.1.4 Creemers's theory of school effectiveness

School effectiveness research is the association between factors in the school that enhance school effectiveness and output measures (learner performance).

Scheerens's model of school effectiveness has three broad approaches to school effectiveness modelling, namely the economic approach, the educational-psychological approach and the generalist-educationalist approach (Scheerens, 2004).

The economic approach dates back to the Coleman report (Coleman et al., 1966) in the 1960s when production functions were utilised in economic research. These models were designed to measure the relationship between individual variables and learner achievement. The focus in this approach was to determine the influence of family background factors on learning achievement (Riddell, 2008). In general the outcome of these models in developing countries showed that what had the most significant impact on learning outcomes was the quality of the schools and teachers that learners were exposed to (Riddell, 2008).

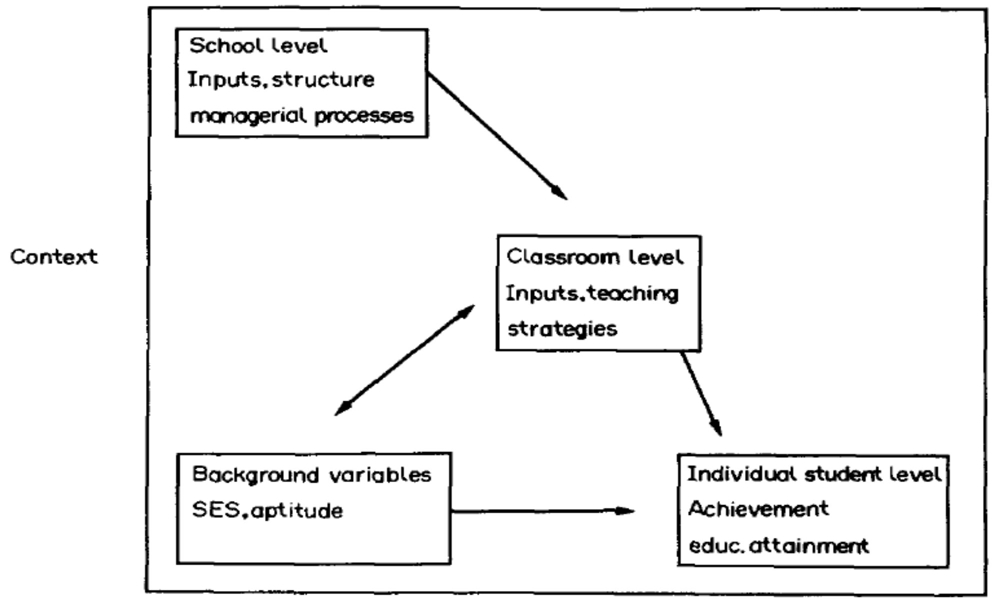
The second approach, educational-psychological approach to educational effectiveness modelling, focuses more on process variables like teaching style. This approach is based more on educational theory than the economic approach (Bennett, 1976; Gray, McPherson, & Raffe, 1983) . The focus in this approach is more on the classroom and the processes that take place in the class like time spent on learning, teacher education, teacher experience, class size and educational resources. Carroll (1963) developed the "educational productivity" model that consists of five categories of variablse that explain variation in school achievement. The five categories included in the model are aptitude, opportunity to learn, perseverance, quality of instruction and ability to understand instruction.

The third approach, the generalist-educationalist approach, began in the late 1980s and is generally used today. Since the first approach to school effectiveness in the 1960s until the early 1980s all research in school effectiveness was modelled using either the first approach (economic approach) or the second approach (educational-psychological) but not a combination of the two. In fact, after the release of the Coleman report in 1960 that basically concluded that schools had no effect on learner performance and that learner background was more important, research was focused on the family and only in the late 1980s an attempt was made to integrate the first two approaches to create the third approach.

Researchers realised that the factors affecting educational quality was a complex web that was intertwined at different levels and could not be discussed independently. Thus the generalist-educationalist approach resulted in models with a multilevel structure (Raudenbush & Bryk, 2002) where schools are nested within context, classrooms within schools and learners within classrooms.

One of the first models that implemented the generalist-educationist approach was developed by Carroll in 1963. Carroll stated that a learner's ability to master a concept is a function of the ratio of time spent doing the work to the ratio of the time allocated to a learner to do the work. In 1989, Carroll pointed out a flaw in the model in that it does not factor in the quality of instruction. Hence in 1994 Creemers, using Carroll's (1963) model of learning as a basis, added the component of quality of instruction to Carroll's model (Kyriakides, Campbell, & Gagatsis, 2000). Creemers identified three components of quality, namely curricular material, grouping procedures and teacher behaviour, and then added it to Carroll's model. Another difference between Carroll's model and that of Creemer is that Carroll's model focuses on the learner whereas Creemers's model explains why educational systems perform poorly and is based on the assumption that learner achievement is multilevel (see Figure 2.3).

Figure 2.3: A multilevel model of school effectiveness (Scheerens & Creemers, 1989, p. 709)



Research in the field of education where Creemers's model was implemented (Kyriakides & Tsangaridou, 2004; De Jong, Westerhof & Kruiter, 2004) has shown that it is important to do a longitudinal type analysis in order to measure school effectiveness rather than once off studies. A study done in Cyprus utilised Creemers's model to examine whether pupils, classrooms and school variables have an effect on learner Mathematics performance (Kyriakides et al., 2000). The results showed that the net effect of classrooms was higher than that for schools and hence concluded that influences on learner achievement are multilevel (Kyriakides et al., 2000).

Thus Creemers's (1994) model has a multilevel structure with schools nested in context; classrooms within schools and learners within classrooms. This model is used in the current study where the outcome is learner performance in Mathematics or educational quality. The next section provides some background on the multilevel modelling of educational data.

2.2 Multilevel modelling of educational data

The main aim of school effectiveness research is to determine or evaluate the impact of a combination of learner, school and classroom factors on learning outcomes (Teddlie & Reynolds, 2000). These factors are interrelated and hence it is impossible to separate the effects of a school from that of a class from that of a learner (Raudenbush & Bryk, 2001). An analysis method is then required that allows for the nested nature of educational data to be considered without any information being lost, as would be the case if data at the learner level was aggregated to the school level, but also similarly if disaggregation was done from the school to the learner level. Burstein posits that education occurs in some or other group context and that the educational exposure that learners receive occurs in groups to which they belong (Burstein, 1980). Learners from a particular classroom come from communities that are more homogeneous in terms of family background, socio-economic status and race to mention a few demographic factors. Furthermore, learners in the same classroom share the experiences of being with the same teacher and physical environment which may lead to homogeneity over time (Lee, 2000).

Traditional statistical methods like analysis of variance (ANOVA) and ordinary least squares (OLS) regression do not take the multilevel nature of educational data into account and when used lend themselves to statistical difficulties like deciding what unit of analysis to use, for example, the learner or the school (Lee, 2000). Statistical errors that are also encountered are aggregation bias, incorrectly estimated standard errors and heterogeneity of regression (Lee, 2000; Hungi & Thuku, 2010).

2.2.1 Unit of analysis

In previous research studies (Carroll, 1963; Coleman, 1988), when learner and school factors and their impact on performance were discussed, deciding on the unit of analysis proved difficult conceptually and methodologically. Depending on the focus of the research being studied either at the learner or school level it meant that data had to be either aggregated from the learner level data to school level data if the unit of analysis was the school, or disaggregated to the learner level if the unit of analysis was the learner (Hox, 1995; Lee, 2000). This method of analysis would result in aggregation bias which means that the variable could take on a different meaning once aggregation or disaggregation has occurred. Error terms of higher order coefficients become a problem because significance tests are based on the unit with the largest number of observations. Hence this method would be biased towards the learner because they have the largest number of observations. This is the problem with the Coleman report (Coleman, 1988), which states that schools do not have an impact on educational quality and that only learner background variables are important.

2.2.2 Misestimated standard errors

A standard assumption of ordinary least squares (OLS) regression is that of the independence of observations. This assumption, however, does not hold true for multilevel data in the sense that learners within the same class, taught by the same teacher, would be dependent as opposed to independent because they share similar characteristics (Raudenbush & Bryk, 2001) Hence standard errors produced by

OLS regression will be too small for data that has been aggregated and will result in a higher probability of rejecting the null hypothesis (Osborne, 2000).

2.2.3 Heterogeneity of regression slopes

One of the assumptions of ordinary least squares regression is that of homogeneity of variance, implying that the variance displayed by the dependent variable (learner performance) across the range of independent variables is the same; no school differences are observed. When analysing educational data, however, homoscedasticity is not possible because schools differ by virtue of their geographical location. In South Africa geographical placement and socio-economic status (SES) are linked and learners from schools in wealthy areas often perform better than learners from schools in low SES areas (Frempong et al., 2011). This being said, it is clear that schools in the sample would be heterogeneous and this violates the OLS assumption. Multilevel modelling is an extension of ordinary multiple regression. OLS regression estimates a single equation and does not allow for school differences, whereas multilevel analysis, on the other hand, takes school differences into account and respects the heterogeneity of social data structures (Paterson & Goldstein, 1991). Multilevel analysis is thus the method of analysis employed in the current study as it allows for between and within school differences to be analysed and aggregation bias is prevented. The assumption of independence is not necessary in multilevel analysis and standard errors are not misestimated because no aggregation or disaggregation is performed as data at the different levels is kept separate.

2.3 Multilevel modelling of educational data in the South African context

Not much research using multilevel analysis in the field of education has been done in South Africa and articles that have been published use data from studies conducted prior to 2004 (Gustafsson, 2007; Hungi & Thuku, 2010; Lee, Zuze, & Ross, 2005; Smith, 2011; Van der Berg, 2008). Most of the articles published using multilevel modelling made use of the SACMEQ data due to the nested data design. One article in particular written by Lee, Zuze and Ross (2005) used a hierarchical linear model to determine the school level factors associated with its effectiveness in 14 sub-Saharan African countries. The main finding from the article was that schools in urban areas were associated with higher achievement scores, more resources and higher qualified teachers when compared to schools in rural areas.

Using multilevel analysis Hungi and Thuku (Hungi & Thuku, 2010) analysed the SACMEQ data of 14 southern African school systems collected in 2002. The aim of the analysis was to compare the quality of education offered to primary schools in these countries. The results showed that South Africa, Uganda, and Namibia showed the largest variation between schools. The study also found that significant factors that affected quality were grade repetition, socio-economic status, speaking the language of instruction at home and learner age.

By using HLM and the most recent release of the TIMSS Grade 9 data the current study hopes to add to the already sparse research on the multilevel nature of educational data in South Africa and at the same time provide analysis that is recent and could have an impact on policy

2.4 Educational quality

South Africa is one of 164 countries that adopted the Dakar Framework for Action in 2000 along with the six goals clearly stated in the framework. These are the goals (Howie, 2011):

1. Expansion of early childhood care and education;
2. Achievement of universal primary education (98% of learners between ages 7 and 15 are currently at school in South Africa);
3. Development of learning opportunities for youth and adults;
4. Spread of literacy;
5. Gender equality in education;
6. Improvements in educational quality.

After this conference efforts across all countries were geared at ensuring that all children had access to schools although very few new schools were being built

(Modisaotsile, 2012). This has led to over-stretched education systems due to problems like large class sizes, lack of instructional resources and large numbers of unqualified and under-qualified teachers. This has resulted in a drastic drop in the quality of education in many countries. Crouch (Crouch & Penny, 2006) however; argue that this was not necessarily the case and that in fact many countries did not suffer the access-quality trade-off. It would seem that many countries managed to find a balance between access and quality where learners entered the system in large numbers but not at the cost of quality (Cuadra & Moreno, 2005). Many countries attended policy courses to enable them to develop policies properly that, for example, catered for the improvement of teacher experience (Crouch & Penny, 2006). Many countries were able to implement measures to assist learners from poor backgrounds because the impact of SES on learner performance is said to be far-reaching.

Southern Africa and in particular South Africa, however, was not able to make the access transition without it having a dire impact of quality. These countries were unable to find a balance and hence large imbalances exist between access and quality. The low levels of quality received by learners in schools are due to a lack of effective teaching practices and accountability of teachers and school managers (Chisholm, 2004).

Prior to 1994 all spending in education was determined on a racial basis; however, between 1994 and 1999 the Government took great strides and implemented many initiatives in an attempt to improve access, equity and quality across all race groups by 2004. The minister of Education at the time; Professor Kadar Asmal (South Africa. Dept. of Education, 2000) identified nine priorities (Chisholm, 2004) based on the need to accelerate service delivery and enhance accountability of the public service (teachers). These priorities were aimed at improving the professional quality of teachers and at promoting learning through outcomes-based education (South Africa. Dept. of Education, 2000); among these was the status and quality of teaching as well as learner achievement.

When the matriculation results came under scrutiny, however, attention was shifted to matriculants and initiatives were put in place to improve matriculation pass rates, especially in previously black (prior to 1994) schools. A pass rate as defined by the Department of Basic Education is the number of learners who passed Grade 12 as percentage of those who sat for the examination. By 2011 the pass rate had improved from 58.1% in 1994 to 70.2%. The matriculation pass rate for 2012 was 73.9% which is an improvement of 3.7% from 2011. This would seem impressive but what needs to be remembered is that only 45.2% of matriculants actually sit for the examination with more than 50% dropping out before their matriculation year (Scherer, 2013). Grade 12 learners are issued with a school-leaving certificate if they obtain an average of 35%, implying that they have passed Grade 12. This, however, poses a problem if these learners want to progress to tertiary institutions because they need to have obtained at least 50% for entry into a tertiary institution and in 2012 only 26.6% of learners obtained a matriculation exemption and were eligible for entry to a university. This speaks volumes of the calibre of matriculants that the country is producing (Scherer, 2013) as well as the quality of education being provided to learners.

With all the emphasis being placed on the relevance of matriculation and pass rates it seems that quality in the lower grades has suffered and hence is still exceptionally poor.

It is expected that after the first three years of schooling children should be able to read fluently, which, however, is not the case in South Africa. In fact, grade level testing shows that after Grade 6 many children still cannot read and are unable to do basic Mathematics (Hewlett Foundation, 2008).

It is understood that education is vital in shaping an individual’s life opportunities because the higher a person’s achieved level of education the higher the returns on the person’s economic and social status (Levin, 2001).

In an attempt to examine the relative effects of family and school on achievement Ilie and Lietz (2010) used a model developed by Heyneman and Loxley (1983) . The model consists of four blocks:

- Preschool (family) block that includes parental education, occupation, number of books in the home and dictionary use, and learner gender and age;
- School track (academic or vocational);
- School programme which includes school type;
- School variables included are total learner enrolment, number of Science teachers, opportunity to learn, Science textbooks, and hours of homework per week.

The results reported by Ilie and Lietz (2010) show that if the language of instruction and the home language are the same, and if the learners have access to books in the home, and if they are younger or at the grade appropriate age, and if they have parents who are highly educated, then learners perform better than their counterparts.

2.5 Factors affecting educational quality

The organisation and improvement of quality of schools can only be successful if connections are made between the home, the school and the community (Sanders & Epstein, 2005) .

New education policies were developed to correct the inequalities of the apartheid education system (prior to 1994). All emphasis was placed on the school and teachers where policy documents created referred to equipping unqualified and under-qualified teachers and holding school managers accountable. Much emphasis was placed on curriculum change and the successful implementation of the said curriculum by schools and teachers. Accountability was the strong message that enabled monitoring of school and teacher quality to take place. It is clear and substantiated by research that problems in the education system exist in South Africa even though the MDG target of universal education has been met. Of the learners who enter the education system at Grade 1 only 45.2% proceed to Grade 12 (Modisaotsile, 2012); this state of affairs could be indicative of a poorly managed system and possibly one where the quality is questionable.

Using the model of school effectiveness mentioned earlier this review seeks to list the factors at the learner level (variables are age, a comparison of the mother tongue and that of the language of instruction, family structure, family socio-economic status, adult involvement, home educational resources, bullying and learner attitudes towards learning Mathematics) as well as those at the school level (class size, infrastructure, shortage of educational resources and teacher working conditions) that have been known to be associated with educational quality.

2.5.1 Learner contextual factors affecting educational quality

2.5.1.1 Family socio-economic status (SES)

A learner level variable that has been investigated in some detail is that of family socio-economic status (SES). SES is an indicator often used to measure the wealth or possessions of a family with regard to physical possessions in the home, such as having a television, computer, running water and a child having his/her own room, to name but a few. A commonly used indicator of SES is family income, parental education and fathers' occupation (White, 1982). Parental education and qualification in most studies are also included to create the SES variable.

Sirin, 2005 posits that socio-economic status directly affects learner achievement but also has indirect implications through interacting systems. These include the learners' racial background and school/neighbourhood location. Learners who fall in high SES categories will in all likelihood live and go to schools in more affluent neighbourhoods, have access to more resources in the home and will most likely have better supportive relations with parents and between parents and schools (Sirin, 2005; Hungi & Thuku, 2010) and are thus more likely to succeed in school.

In most countries learners who form part of higher SES categories perform better in school than those from lower SES categories; however, in Hong Kong this is not the case where a study conducted showed SES to have no effect on learning outcome (Chiu & Ho, 2006).

2.5.1.2 Family structure

Research shows that the optimal situation for a child is to live in a home with both biological parents because the investment in education is equal and unbiased as both parents have the child's best interests at heart (Anderson, 2003) . Studies suggest that the learner performance of learners from single parent families is lower than learners from nuclear (biological parents) families. The same is true for children from two-parent families that are not biological parents (by virtue of remarriage or cohabitation) (Amato & Keith, 1991; Hetherington & Jodl, 1994). A possible reason for this is that often the cohabiting parents have children from previous relationships and this could mean less parental involvement with children.

Research shows that family structure plays a role in determining the extent of parental involvement in a child's life. Riley (1996) stated that biological parents not living with a child spend less time with that child. Single parents are not able to spend as much time with their children as they would like because they may be employed at more than one place in an attempt to make ends meet (Jeynes, 2005). Research has shown that children from two-parent households perform better academically because such parents invest more in educational resources in the home and are more involved in their children's schooling (Downey, 1995) .

The effect of family structure on learner performance seems inconsistent with some researchers saying that there are small but significant effects (Hauser, 1971); Milne and co-researchers (1986), however, found marked effects between family structure and performance (Milne, Myers, Rosenthal, & Ginsburg, 1986). Entwisle and Alexander (1990) found that family structure has no impact on learner performance.

2.5.1.3 Parental involvement

Parental involvement in the context of the current study refers to statements that learners were asked to respond to. The statements placed much emphasis on homework and parental interest in school matters. Hoover-Dempsey and Sandler in 1997 state three reasons why parents get involved in homework: it is their parental duty, they believe being involved will result in positive outcomes and parents recognise invitations (cues picked up from the teacher or the child) to get involvement (Hoover-Dempsey, & Sandler, 1997). Learner performance is influenced by parental involvement because it is linked to psychological attitudes (social, behavioural and cognitive) that support learning (Hoover-Dempsey et al., 2005). Hence learners who experience positive motivation at home are inclined to be positively motivated in learning a subject and have positive outcomes.

Research has shown that there are three types of parents: those who are involved, those who are overly involved and then those who are not involved at all. A positive relationship exists between parental involvement and learner performance (Sui-Chu & Willms, 1996). However, a negative relationship is observed if parents are overly involved in a learner's school work which could result in less or no responsibility taken by the learner (Hoover-Dempsey et al., 2005). The expectation of the parent is that the teacher or school needs to prioritise his or her child with disregard for the other learners in the class. This type of parental involvement has a negative effect on learner performance. A negative relationship exists between learner performance and uninvolved parenting. Learners of parents who are involved in the school work score higher on average than learners whose parents are not involved (Hoover-Dempsey et al., 2005). As has been mentioned, parental involvement in the wellbeing of the child is instinctive to all parents but unfortunately the situation that parents often find themselves in leads to their not being able to assist a learner with his or her homework. In many cases learners come from homes that are headed by single parents that have to work long hours (Jeynes, 2005) to ensure that they are able to cope financially. For these parents being involved in homework or school activities is impossible. Research shows that a very high parental interest is associated with higher achievement levels and vice versa (Feinstein & Symons, 1999). A fourth research finding with respect to parental involvement is that it is not related to learner performance and is found to be insignificant (Chiu & Ho, 2006). A reason for the insignificant association could be how parental involvement is defined. Some studies define it by the resources that parents make available to do homework which has been found to be an insignificant predictor of learner performance (Desimone, 1999).

2.5.1.4 Home educational resources

Educational resources in the home can be viewed as goods- and time inputs (Murnane, Maynard, & Ohls, 1981). Goods inputs refer to physical material type inputs like food, clothes, accommodation and books in the home to assist with homework. Time inputs, on the other hand, are about parental time spent with children, for instance assisting with homework, talking about school and other topics as well as reading to the child. A measure used by Murnane (1981) to gauge time input is maternal education because it is evidenced that mothers who are more educated spend more time with their children (Datcher-Loury, 1988) and they are more able to offer intellectual stimulation than uneducated mothers. The study found that goods inputs, however, are not related to learner achievement.

Family resources are an important socio-environmental factor that has a strong and immediate influence on learning achievement. This is consistent with studies conducted on the vital role of family background or social capital on learning processes (Gonzalez & Sibayan, 1988; Sirin, 2005).

2.5.1.5 Home language (mother tongue) same as test language

Currently in South Africa all learners in the foundation phase are taught in the mother tongue; however, from the intermediate phase of school until the senior phases English is the medium of instruction in most South African schools; instruction in a second or additional language is believed to impede learning because it is not the home language (Heugh, 2005). Heugh believes that it is impossible for a learner to have learnt enough by the third grade for a second language switch to be considered. In ideal situations, with schools having sufficient resources and qualified teachers, a learner would need six to eight years to master a second language before it should be used as a medium of instruction; no switching should occur before Grade 7 (Heugh, 2005).

A six-year longitudinal study conducted by Fafunwa and co-researchers (1975) showed that learners taught in their mother-tongue for the first six years of school obtained higher results than those taught purely in English. However, a study done in Gonzalez and Sibayan (1988) found the largest determinant of low learner achievement was not bilingual education but rather the low quality of teacher training.

The relationship between home language and language of instruction on performance was insignificant and hence suggests that home language is not an important factor in learner performance (Maree, Aldous, Hattingh, Swanepoel, & Van der Linde, 2006). A large amount of literature is available in favour of mother tongue instruction (Heugh, 1995; Luckett, 1995; Pluddemann, 1996, Hungi & Thuku, 2010).

2.5.1.6 Learner attitudes towards learning Mathematics

A learner's attitude towards learning Mathematics is vital in determining his or her success in Mathematics performance (Organisation for Economic Co-operation and Development, 2004; Zan & Martino, 2007). In the current study three aspects of learner attitude are considered. Learners' who are "confident" in learning Mathematics are also generally learners who "like" and "value" Mathematics and these positive attitudes toward Mathematics result in positive Mathematics performance. Extensive research has been done in the field of learner attitudes towards learner performance but the outcomes seem contradictory. Some research has found that a positive and significant association between learner attitudes and Mathematics performance (Organisation for Economic Co-operation and Development, 2004). Papanastasiou (2002) on the other hand, found the relationship between learner attitude and performance to be insignificant. Research has shown that negative relationships exist as well (Mullis et al., 2000) ; for example, in the TIMSS studies the Japanese students outperform many other countries, yet they have a negative attitude towards Mathematics.

Important to note is that learner attitude towards Mathematics is not purely intrinsic and that extrinsic factors like a parent or teachers attitude can determine the learner's attitude toward Mathematics (Fisher & Rickards, 1998). Teachers should develop a positive attitude and relationship with learners. Similarly parental involvement is then vital in instilling a positive attitude towards Mathematics in the learner that will aid the learner in performing well in the subject.

2.5.1.7 *Grade specific age*

In South Africa there appears to be a general problem, not so much with under-aged learners but more so with over-aged learners in the education system. Muller (1998) theorises that learner access and learner drop-outs are not the main concern in schools but rather that learners enter the system (Grade 1) when they are too young, which results in large scale grade repeating up to Grade 12. He posits that the most pressing issue is not getting learners into school but rather finding a way to get them through school. Studies have shown that grade repetition, drop-out and late start are three factors that cause overage in schools, with the primary cause being repetition (Deparment of Basic Education, 2011). In a study carried out in Malawi (Kunje et al., 2009) found that age is significantly related to learner performance and that learners at the grade appropriate age perform better than under- and overage learners.

Crosser (1991) as well as Kinard and Reinherz (1986) showed that older learners perform better academically than younger learners. DeMeis and Stearns (1992) found no significant difference between age and learner achievement. Grissom found that a positive linear relationship exists between age and learner achievement in the younger grades; however, the relationship becomes a negative one in the later years. He found that grade age appropriate learners outperform those learners who are overage (Grissom, 2004).

2.5.2 School contextual factors affecting educational quality

2.5.2.1 School climate

School climate in education research has been defined by researchers in different ways but the definition most appropriate for the current study is the one by Haynes and co-researchers (1997); it states that "School climate refers to the quality and consistency of interpersonal interactions within the school community that influence children's cognitive, social and psychological development" (Haynes, Emmons, & Ben-Avie, 1997, p 322). It also refers to the school's beliefs, values and communication between learners, teachers and administrators.

Research shows that a healthy school climate has a positive effect on learner achievement (Dupper & Meyer-Adams, 2002). Stewart posits that learners, who feel accepted, respected and supported (Stewart, 2008) perform better than those who are not respected and supported. A strong relationship exists between school climate and achievement where school climate variables account for 72% of the variance explained in learner achievement (Brookover et al., 1978).

A positive school climate is very important for the health of the school system but all the more so for the success of the learner (Lee & Bryk, 1989; Shields & Shaver, 1991) .

2.5.2.2 Bullying

Bullying as defined by Rigby in 2007 is "repeated oppression, psychological or physical, of a less powerful person by a more powerful person or group of persons" (Rigby, 2007, p. 15).

Learners who are bullied at school generally feel unsafe and less connected to the school than learners who are not bullied; they also obtain lower scores than their peers. The Trends in International Mathematics and Science Studies (TIMSS) International Mathematics report shows that 75% of South African learners are bullied on at least a monthly basis (Mullis, Martin, Foy, & Arora, 2012). This is an alarmingly high percentage, showing that three quarters of learners have been bullied and are most likely still being bullied. The TIMSS report also shows that learners who are not bullied score on average 51 points more than learners who are bullied (Mullis et al., 2012), which clearly shows that bullying has a negative impact on learner achievement (Nakamoto & Schwartz, 2010). Research shows that learners who are bullied are at least a grade and a half behind their peers who are not bullied (Juvonen & Graham, 2004).

Research conducted by Skrzypiec in 2008 shows that a third of learners who are bullied also show signs of lack of concentration in class due to the fear inflicted by bullying (Skrzypiec, 2008). Such learners also obtain lower scores than their peers who are not bullied.

2.5.2.3 Class size

Research shows that large class sizes negatively affect performance (Stewart, 2008). In smaller classes more individualised attention is paid to learners, which creates more opportunities for involvement; this in turn results in positive learner behaviour and in turn in better results (Johnson & Stevens, 2006; McMillen, 2004). A study conducted by (Fuller & Clarke, 1994) found that class size had no effect on learner achievement. In comparing developed countries to developing countries research done by Scheerens (2000) found that in developing countries class size had a significant impact on learner achievement; the opposite was true for developed countries where the focus was on instruction. A reason for this is possibly the large between school variations that exist in developing countries where the average variation explained by the model is between 30 – 40%. In developed countries however this variation reduces to between 10 - 15% because resources in schools in developed countries are more homogeneously distributed compared to developing countries.

2.5.2.4 School infrastructure and resource shortages

Research conducted in the field of education and specifically dealing with factors affecting learner performance in developing countries generally places emphasis on financial, material and human resource input variables (Scheerens, 2000). With regard to these input variables the ones frequently used were class size, teacher training, general facilities and equipment and instructional time (Fuller & Clarke, 1994; Mwamwenda & Mwamwenda, 1987). Reviews done by Fuller and Clarke suggest that the most significant positive relationship with learning outcomes are the availability of textbooks and reading material, teacher qualities and instructional time and work demands placed on learners.

Research has found that the impact of variables like school organisation and instructional variables are very low (Scheerens, 2000) in developing countries. Research conducted by (Nyagura & Riddell, 1993) found very little association between instructional time devoted to learning and professional support to teachers by principal supervision; however, variables having the greatest impact are textbook availability and teacher training.

Glewwe and co-researchers (1995) reported on a study conducted in Jamaica and concluded that variables like teacher practices in the classroom are positively related to performance, more than variables that relate to school organisational variables, curriculum, instructional time and teacher quality (Glewwe, Grosh, Jacoby, & Lockheed, 1995). This is, however, contradictory to findings of a study by Van Der Werf and co-researchers (2000) that found variables like time spent on a subject, frequent teacher evaluation and assistance at home to be the most significant (Van Der Werf, Creemers, De Jong, & Klaver, 2000).

2.5.2.5 Teacher working conditions

Four resources that have proven to be important when discussing teacher working conditions are adequate physical conditions, an orderly environment, instructional resources and reasonable workloads (Johnson, 2006). Adequate physical conditions refer to facilities at the school that are well maintained and have enough space. Rosenholtz and Simpson (1990) found a strong correlation between teachers' commitment and the condition of physical resources. Teachers internalise lack of physical resources and are convinced that they are not valued by the school. With regard to school climate or orderly environment Corcoran and co-researchers (1988) found that schools with a better climate are better attended by learners and have more committed teachers (Corcoran, Walker, & White, 1988). A strong correlation exists between school climate and teacher commitment and satisfaction (Kushman, 1992).

Instructional resources refer to textbooks, blackboards and science material (Firestone & Rosenblum, 1988) and a lack of these relates to poor working conditions for the teacher and in turn to poor academic results. Reasonable workloads that allow teachers adequate time for preparation and monitoring of learners result in teachers who feel valued and looked after and this in turn results in improved learner achievement scores.

2.5.2.6 Teacher qualification, specialisation and experience

Schiefelbein and Simmons (1981) reviewed studies conducted in more than 20 countries and found that in 19 of the 32 studies reviewed, that learners taught by qualified teachers did not perform any better than learners taught by unqualified or under-qualified teachers. They found a positive effect between years of experience and learner achievement in only seven of the 32 studies (Schiefelbein & Simmons, 1981a).

Hanushek (1995) states that variables like teacher education, facilities and teacher experience are positively related to learner achievement (Hanushek, 1995).

Many researchers have argued that teacher quality is an important factor in explaining educational quality (Lee *et al*., 2005). How well prepared teachers are has a direct effect on learner achievement; Darling-Hammond (1997) concludes that it is even more important than the learner's background, SES, language and race (Darling-Hammond, 1997). She also states that teacher quality is more strongly related to learner performance than any other kind of investment in the school like class size and teachers' salary.

Research has found that teacher quality is a better determinant of performance than school quality which in itself is a very important predictor (Sanders & Rivers, 1996). Research has shown that a positive relationship exists between teacher qualification and learner achievement in that higher qualification is linked to better performance (Buddin & Zamarro, 2009).

Another important factor to take note of is not just the qualification of the teacher but rather the specialisation of the subjects taken. Is it a teacher with a general degree, or is it a teacher that has a degree and has majored in Mathematics and Mathematics education? How does subject specialisation impact on learner achievement? In response to this question, research has shown that specialisation has a positive effect on learner achievement (Goldhaber & Brewer, 2000). Learners who are taught by teachers who specialise in Mathematics education or pure Mathematics obtain higher scores than those learners who are taught by teachers who have not specialised in Mathematics (Rowan, Chiang, & Miller, 1997).

2.6 Summary

Since the implementation of the Millennium Development Goals as well as the follow-up conference where educational quality was discussed, countries have spent enormous amounts of money to ensure that all schools in the different countries are able to provide a quality education to their learners. And like all other countries the South African Department of Education has created policies and initiatives to ensure that resources are provided to the previously disadvantaged schools (all poor schools) as well as improved the professional quality of teachers. In addition learner progress is monitored by making use of regular assessments or tests. If improvement in test scores were observed it would translate to improved quality of education.

After the initiatives had been implemented it still showed no change in educational quality because learner scores in large scale assessments like the Trends in International and Science (TIMSS) since 1995 have shown no significant improvement in learner performance (Reddy, 2012). With learner performance being a proxy used to measure educational quality, it would then imply that there has been no significant improvement in the quality of education in South Africa.

It is important to determine what other factors within and outside of the school could contribute to the improvement of the quality of education, or explain the lack of improvement in the quality of education. The model of school effectiveness previously mentioned has assisted in understanding how factors like home background (learner), and school and teacher contextual factors could assist in explaining the lack of quality provided by schools in South Africa. Using this model, the current study aims to determine the learner and school factors that are associated with learner achievement and in turn are associated with improved quality.

The purpose of this chapter is to provide a theoretical framework of models considered for the current study as well as to review literature related to the multilevel methodology used and the factors at the learner and school level that are associated with educational quality.

The chapter that follows provides the conceptual framework for the current study as well as details pertaining to the methods of analysis utilised.

Chapter 3

3 Research Design and Methodology

3.1 Introduction

This study seeks to explore the influence of school and family factors as they relate to Mathematics performance of Grade 9 learners. Information pertaining to family factors as well as school factors was extracted from data obtained from learner, teacher and principal questionnaires used during the data collection of this study.

3.2 Conceptual framework

Educational research is concerned with exploring and understanding social phenomena that are educational in nature (Dash, 1993). In trying to understand these social phenomena a number of theoretical questions in education have emerged and hence different paradigms have evolved that influence the manner in which knowledge is studied and interpreted (Dash, 1993). Due to the remarkable growth in social science research, different paradigms have been utilised during the past century.

A paradigm is a way of looking at the world and the ability to use theories composed of variables as well as statistical methodologies to analyse social and human problems (Kuhn, 1996). It is composed of certain assumptions that guide and direct thinking and action (Mertens, 2007). These assumptions are the following:

a) Ontological assumption that asks the question, "What is the nature of reality?" Simply put, it refers to one's view of reality.
b) Epistemological assumption that refers to the relationship of the researcher to that which is being researched; how one acquires knowledge.
c) Methodological assumption: "What is the process of research?" Methodology is focused on the specific ways (the methods) that we can use to try to understand our world better.

The assumptions mentioned above are elaborated on later in the chapter.

The following three paradigms are generally referred to in educational research:

a) Positivist (Post-positivist) paradigm

It is the first paradigm that guided early educational research and it originated with Aristotle, Francis Bacon, John Locke, August Comte and Emanuel Kant (Mertens, 2007). Positivists believe that one reality exists and that it is the researchers' responsibility to discover this reality (Guba & Lincoln, 1994). Positivism is based purely on scientific methods where the purpose of science is to stick to what can be observed and measured. Positivists operate by laws of cause and effect and believe that by using a specific scientific method they can discern between these laws (Trochim, 2006). By World War II positivists had been criticised for applying scientific methods to research in human behaviour and this was then replaced by post-positivism. Popper argued that all the good qualities of scientific methods should not be discarded but rather that small adjustments are made that will still provide objective research within the social sciences (Popper, 1944). This paradigm relies on quantitative data collection methods.

b) Constructivist paradigm

The constructivist paradigm is referred to as constructivism because emphasis is placed on the ability of an individual to construct meaning. Constructivist approaches to research have the intention of understanding "the world of human experience" (Cohen & Manion, 1994), suggesting that "reality is socially constructed" (Mertens, 2007). Researchers in this area depend heavily on the views and experiences of participants (Creswell, 2003). Constructivists do not depend on theories as is the case of positivists; instead they generate theories or patterns of meaning (Creswell, 2003). This paradigm relies on qualitative data collection methods.

c) Pragmatist paradigm

Pragmatists are not committed to any one system of philosophy or reality (Mackenzie & Knipe, 2006). They focus on the "what" and "how" of the research problem (Creswell, 2003). Pragmatism provides the underlying framework for mixed methods that refer to research that are both quantitative and qualitative.

3.2.1 Approach used for the current study

This study follows the post-positivist paradigm and is situated within a quantitative research approach. The conceptual framework used in the current study will be discussed within the three levels of the research paradigm, namely the Ontological, Epistemological and, Methodological.

3.2.1.1 Ontology (What is the nature of reality?)

Post-positivists believe that a reality does exist but contrary to positivists, they argue that it can only be discovered within the realm of probability.

The ontological assumption in this study is based on previous theories and previous research; the researcher was able to select independent variables that may have an effect on learner performance which is the dependent variable. Using statistical analysis the strength of relationships between the independent and dependent variables was determined within a level of probability.

3.2.1.2 Epistemology (What is the relationship of the researcher to that which is being researched?)

"This paradigm holds that objectivity is the standard to strive for in research; therefore the researcher should remain neutral to prevent bias from influencing the work by following procedures rigorously" (Mertens, 2007, p.11).

In this study fieldworkers were trained in how to field the instrument using procedures. Questionnaires were developed and questions posed to interviewees were phrased exactly as stated in questionnaires.

3.2.1.3 Methodology (What is the process of research?)

Methodology refers to the process of research; causes determine the effects of outcomes. In this study the aim is to test the impact of family characteristics on learner performance and similarly, how school factors indirectly affect learner performance.

3.3 Research problem

The research problem is to examine the impact of learner contextual factors as well as to determine the school factors that affect education quality.

3.4 Aims of the study

Due to the multilevel structure of the data the aims are discussed within the two levels that the analysis will be performed in.

At the learner level the aim is to determine the association between learner background factors and learner Mathematics performance. Variables are mentioned here but more detail is provided in Table 3.2. The following variables are considered:

- **Learner age** is a continuous variable in the instrument but for the purposes of this analysis it was categorised into learners aged 10 to 13 years, 14 to 16 years and those 17 years and older;
- **Family structure** (comparing the nuclear family to that of the single parent family). A nuclear family is one where the children reside with both biological parents as opposed to the single parent family where the children live with either mother or father. The learners were asked who they reside with; it was a multiple response test item where options provided were mother*, father*, *stepmother*, *stepfather*, *grandparent*, *aunt*, *and uncle, guardian*, *boarding master/mistress*, *orphanage manager* and *other*;
- **Parental involvement** (this would include variables like assistance with homework, making time available to the learner to do homework, checking learners' homework and asking about work done at school. Parental

involvement is a measure that consists of a number of different questions that were posed to the respondents;

- **Family socio-economic status** is calculated based on certain amenities found in the house, like electricity, tap water, toilet in the house, computer, newspaper, fridge and washing machine;
- **Language of test same as home language**. A comparison was made of the language in which the test was written, i.e. English or Afrikaans and the language most spoken at home. This variable is a dichotomy with a value of one given to learners whose test language and home language is the same and zero otherwise;
- **Population group** of the learner;
- **Bullying** consists of a few variables that were combined to create a single measure. The variables included in this measure are learners being made fun of, being hit or hurt by other learners and made to do things they do not want to do;
- **Learner perception of school climate** is a measure consisting of three statements that the learner had to respond to;
- **Home education resources.** Learners had to respond *Yes* or *No* to a number of statements related to educational resources in the home;
- **Learners who like Mathematics** are a measure created and consist of five statements where responses ranged from “Agree a lot” to “Disagree a lot”;
- **Learners who value Mathematics** is also a measure created very similar to that of learners who like Mathematics;
- **Learners who have confidence in doing Mathematics** is a measure created and follows a similar structure as “like” or “value” Mathematics.

At the school level the aim is to determine the contextual factors within a school that influence educational quality (learner Mathematics performance). Factors are mentioned here but more detail is provided in Table 3.4. The following factors were considered:

- **Assessment tests** – teachers were asked how often class assessments are done;

- **School resources** – resources that the school has, e.g. instructional material (textbooks), stationery and school infrastructure;
- **Class size** – teachers were asked how many learners they have in their class;
- **School socio-economic status.** This is a composite measure that includes three questions posed to principals. Principals were asked the approximate number of people living in the areas surrounding the school, whether the area surrounding the school is economically affluent or not, and lastly the average income level of the surrounding area;
- **Teachers' perception of school climate** is a measure consisting of a number of variables relating to school climate;
- **Teacher experience** is a continuous variable that indicates how many years teachers have been teaching;
- **Teacher qualifications;**
- **Mathematics as major area of study;**
- **Resource shortages;**
- **Working conditions.**

3.5 Research questions

The aim of this study is to determine the correlation between learner background and school contextual factors relating to learner Mathematics performance. Bearing in mind that multilevel analysis was used to determine this correlation, it is important that the research questions be stated in a manner appropriate to the 2-level HLM analysis utilised. Using the variables as stated in the aims above, the research questions are the following:

1. To what extent are learner contextual variables (i.e. age, population group, family structure, family SES, parental involvement, learner perception of school climate, home educational resources) associated with educational quality (Mathematics performance)?
2. To what extent are school contextual factors like assessments, teacher perception of school climate, school SES, class size, general school resources, teacher experience, teacher qualifications, resource shortages and

working conditions associated with educational quality (Mathematics performance)?

3.6 Research design/methodology

3.6.1 Data source

This study is based on data obtained from a secondary source, namely the Trends in International Mathematics and Science Study (TIMSS). The TIMSS international data has been made publicly available at http://timssandpirls.bc.edu/timss2011/international-database.html.

TIMSS is a study conducted by the International Association for the Evaluation of Educational Achievement (IEA) and aims to improve instruction and learning in Mathematics and Science. It is conducted every five years; the first cycle was conducted in 1995. South Africa took part in four of the five cycles of TIMSS in 1995, 1999, 2003 and 2011. In 1995 and 1999 the study was administered to Grade 8 learners, as is common practice in TIMSS. However, in 2003 the tests were administered to Grade 8 and Grade 9 learners and only to Grade 9 learners in the 2011 round. The TIMSS administration included Mathematics and Science assessments as well as a learner background questionnaire. In addition, the Mathematics and Science teachers as well as the principal of the school were required to complete a background questionnaire.

The 2011 learners' Mathematics scores and all questionnaire data were used for analysis in this study.

3.6.2 Population and sample

To ensure that a learner population as a whole can be estimated accurately TIMSS employs extremely rigorous school and classroom sampling techniques in order to provide valid and reliable measurement of trends in learner performance.

TIMSS employs a two-stage random sampling design where a sample of schools is drawn at the first stage, followed by selecting intact classes within a school at the second stage. TIMSS places considerable emphasis on learner curriculum and instructional experiences that tend to be the same for learners taught by the same teacher and hence in-tact class sampling was done.

TIMSS defines a target population as "Learners enrolled in the ninth year of formal schooling, counting from the first year of primary school", which is the definition used by UNESCO's International Standards Classification of Education (ISCED-2011) and includes all schools regardless of the type of school. South Africa utilised the Department of Basic Educations' "Master list of Schools" as its population or sampling frame of schools. All eligible schools were included in the sampling frame; these are schools that offer Grade 9. South Africa decided to use *province*, *language of instruction* and *school type* as stratification variables and hence all schools that had missing information for any of the listed stratification variables were excluded from the sample.

A factor needing consideration is that of school exclusions from the population or sampling frame. Grounds for exclusion were the following:

- School level exclusions that refer to schools that did not meet the sampling criteria which were:
  - Geographically remote schools that was inaccessible;
  - Extremely small schools (country specific definitions apply) and in the case of South Africa no schools were excluded based on size;
  - If the curriculum followed by a particular school was very different to that offered by the national education system.
- Learner level exclusions:
  - Learners with functional disabilities;
  - Learners with intellectual disabilities;
  - Non-native language speaking learners who were learners not from South Africa and who were unable to speak either English or Afrikaans.

First stage of sampling

Schools were sampled using a systematic, two-stage probability-proportional-to-size (PPS) from the population of schools. This sampling method takes note of the number of schools within each stratum in the population and hence schools are drawn so that they are proportional to the size of the population in the strata. Schools were first sorted by province and within province schools were sorted by the language of instruction (English, Afrikaans, both) and then finally they were sorted by school type which was either public or private. The sample then consisted of 298 schools that were selected using a systematic random sampling approach. When a school was sampled, two additional schools were sampled to serve as replacement schools. The ideal is that the sampled schools be used but if a sampled school refused to take part then a replacement school was used.

Second stage of sampling

At this stage one or more in-tact Mathematics classes was sampled from each sampled school. A class must have a minimum of 25 learners in it; if a class has fewer than 25 learners then two classes are combined to form a pseudo-class prior to sampling. In such cases two Mathematics teachers and two Science teachers (one per class) are selected for part of the TIMSS cycle. If however the same teacher teaches both selected classes then a single teacher questionnaire is completed. Table 3.1 provides the outline of the number of schools and learners selected in the sample as well as the population of Grade 9 schools and learners.

Table 3.1: Realised sample versus population of schools and learners

Province	**# gr 9 sampled schools**	**# eligible gr 9 schools in population**	**# gr 9 sampled learners**	**# eligible gr 9 learners in population**
Eastern Cape	29	2894	1062	148877
Free State	23	391	865	58682
Gauteng	53	836	2008	158087
KwaZulu Natal	45	2060	2180	218935
Limpopo	27	1667	1255	148999
Mpumalanga	35	521	1640	69954
Northern Cape	22	208	882	20992
North West	24	451	924	54009
Western Cape	27	391	1153	74748
Total	**285**	**9419**	**11969**	**953284**

3.6.3 Instruments

TIMSS administers written tests in Mathematics and Science to Grade 9 learners as well as sets of questionnaires to obtain information on the educational and social contexts for achievement. What is vital to TIMSS is that all learners across all countries are assessed in a manner that encompasses as much of a country's curriculum as possible and at the same time allows countries to measure change between TIMSS cycles. Some detail pertaining to the tests and questionnaires is now provided.

3.6.3.1 Learner achievement booklet design and administration

With each cycle of TIMSS, Mathematics and Science test questions/items are added to the pool of already existing items. At the beginning of a cycle a proportion of the items used in the previous cycle are repeated in the next cycle, allowing for trends to be measured and the remainder of the items are released into the public domain and new items are then added. By releasing items into the public domain, countries are enabled to do their own analysis and also to use the released items as exemplars to learners within countries in preparation of the next cycle. With this constant addition of items since 1995 it would be impossible for a learner to be tested on all the items in a single testing period, which is estimated to last at most 90 minutes for Grade 9 learners.

For this reason TIMSS employs a matrix-sampling approach which simply means that all the Mathematics and Science items are grouped into numerous blocks containing 12 to 18 items, each ensuring content and cognitive domain coverage within each block. TIMSS has a total of 28 blocks of items of which 14 cover Mathematics and 14 Science. Learner booklets (14 booklets) are composed of 2 Mathematics blocks and 2 Science blocks. Each item appears in two booklets that allows for linking between learners and each booklet contains two Mathematics blocks (sets of items) and 2 Science blocks. Of the 28 blocks of items 16 blocks (8 Mathematics and 8 Sciences) are kept to serve as trend items and the remaining 12 blocks (6 Mathematics and 6 Science) are released into the public domain. Each TIMSS assessment booklet is divided into two parts and learners complete the first part, which takes approximately 45 minutes, and then have a break. The break is followed by the second part of the test for about 45 minutes and then the learner contextual questionnaire is completed after another break.

3.6.3.2 Contextual Questionnaires

Three different contextual questionnaires are administered, one to the sampled learners, one to their Mathematics and Science teachers and one to the principal of the sampled school. The aim of these questionnaires is to obtain background information that assists in explaining instruction and learning in Mathematics and Science because learning takes place in a context and not in isolation.

The learner questionnaire is completed by the sampled learners who take the TIMSS Mathematics and Science assessment tests. The questionnaire covers some demographic details of the learner, aspects of the learner's home (home environment) and school life (school climate for learning and self-perception and attitudes towards Mathematics and Science).

Two teacher questionnaires are administered, one for the Mathematics teacher and one for the Science teacher of the sampled classes. Areas covered in these questionnaires are subject specific and ask the teacher about aspects of the classroom context for the instruction and learning of Mathematics and Science, characteristics of teachers (years of experience, qualification, job satisfaction, etc.) as well as Mathematics and Science topics taught. The questionnaire is completed in approximately 30 minutes.

The school questionnaire is completed by the principal and asks questions related to the school (infrastructure at the school, instructional time provided, curriculum coverage, etc.). It takes the principal approximately 30 minutes to complete.

3.6.4 Variables included in the current analysis

The selection of the variables for this study was based on a school effectiveness and school improvement article that was written by Willms and Somer (2001).

The dependent variable is Grade 9 Mathematics performance and serves as a proxy for educational quality (UNESCO, 2004; ECOSOC, 2010). As previously mentioned, not all the TIMSS items were administered to each learner, which meant that a total score per learner was not possible. An estimate for each learner was calculated using Item Response Theory (IRT) and five plausible values per learner were generated. The international study centre in Germany developed an analysis software package called International Data Base (IDB) Analyser that makes it possible for TIMSS data to be analysed with special attention being placed on the complex sampling design and taking the five plausible values into account during analysis. This software was used in this study to create an average learner score so that descriptive analysis could be performed. However, with the HLM analysis (more detail will be provided later in the chapter) all five the plausible values were used because the multilevel package allows for plausible value analysis.

A series of independent variables was selected and was grouped into learner/home background factors (taken from the learner questionnaire) and school contextual factors (taken from the teacher and the principal questionnaire). The variables included in the analysis are mentioned in Section 3.4; however, the section that follows next provides the details of derived variables (one or more variables recoded to create a new variable) and composite measures where a number of variables measuring the same construct, for example "parental involvement", are grouped together. The last type of variable included in the analysis was TIMSS indices, which are composite measures assigned to learners; these can be one of three levels (low, medium or high). TIMSS indices were not calculated in this study but were provided with the released data by the TIMSS international study centre. Details pertaining to these types of variable are provided in the next two sections that are referred to as learner home background and school contextual factors.

3.6.4.1 Learner home background factors

Table 3.2 provides an outline of the variables utilised at the learner level in this study. The variables are either individual questions taken directly from the learner questionnaire, derived variables or composite measures and International TIMSS indices (Table 3.2, column 2).

Table 3.2: Variables included in the analysis (variable names appear in brackets)

Variable (SPSS variable)	Origin of variable	Response option codes	Label
Age (Age)	Dichotomised variables	0	10 - 13 years
		1	All other age groups
		0	14 - 16 years
		1	All other age groups
		0	17 and older
		1	All other age groups
Black/African (Race)	Dichotomised variables	1	Other
		0	African
Test language versus home language (LoLt)	Derived variable	0	Test language not the same as the home language
		1	Test language the same as the home language
Family structure (Nuclear)	Derived variable	0	Two-parent family
		1	Single parent family
Family socio-economic status (SEScat)	Composite measure	0	Low
		1	Medium
		2	High
Adult involvement (AdultInvcat)	Composite measure	0	Seldom
		1	Weekly
		2	Daily
Learner perception of school climate (SchClimcat)	Composite measure	0	Unacceptable
		1	Acceptable
		2	Very good
Home educational resources (HMEEdRes)	TIMSS indices	0	Few resources
		1	Some resources
		2	Many resources
Bullying (Bully)	TIMSS indices	0	Almost weekly
		1	About monthly
		2	Almost never
Learner likes Mathematics	TIMSS indices	0	Do not like learning Mathematics
		1	Somewhat like learning Mathematics

(LikeMath)		2	Like learning Mathematics
Learner values Mathematics (ValMath)	TIMSS indices	0	Do not value
		1	Somewhat value
		2	Value Mathematics
Learner is confident in doing Mathematics (ConfMath)	TIMSS indices	0	Not confident
		1	Somewhat confident
		2	Confident in learning Mathematics

Two variables were derived (Table 3.2, column 2) and included in the analysis. A derived variable is one that is either a combination of two variables or a variable that was created from a set of multiple response variables. In this study two such variables were created, i.e. comparison of the home- and test language variable and the family structure variable. Recoding and composite measures were created using SPSS software, a statistical package used for social science research (Field, 2009).

Family structure is a multiple response test item in which learners were asked who they lived with. The options provided were *mother and father, stepmother and stepfather , mother only, stepmother only, father only, stepfather only, sister or brother, stepsister or stepbrother, grandparent, aunt or uncle, guardian, boarding master/mistress, orphanage manager*. The multiple response options were recoded to create a new variable of family structure with categories for two-parent or nuclear families (biological or step), and all other family types were grouped. When dealing with dichotomised variables in the HLM analysis the category with the zero code served as the reference category, because the aim was to compare other family types to that of 2-parent families the code zero was assigned to 2-parent families (see Table 3.2).

Important in most educational research on factors affecting learner performance is the comparison between the home language and the language of testing. One of the reasons why language of instruction was included as a stratification variable during sampling was to test whether performance is affected if these languages differ. Thus, in this study, a variable was created to compare the language of the test to that of the language spoken at home. This newly derived variable is dichotomous and a code of zero was given to learners whose test and home language were the same and a one if they differed (see Table 3.2).

The composite measures created were parental involvement, learner perception of school climate and family socio-economic status (SES).

"Adult involvement" in the learners' school work at home was the first composite measure created. Four questions were taken from the learner questionnaire and used to create this measure. These questions were Likert scale-type questions and the responses ranged from 1 "Never or almost never" to 4 "Daily or almost every day". Questions included in the measure are the following:

- My parents ask me about what I learn at school;
- I talk about my school work with my parents;
- My parents make sure that I set aside time for my homework;
- My parents check if I do my homework.

The reliability analysis provided a Chronbach alpha of 0.763, implying that the internal consistency among the four questions is acceptable. The four variables were then added together to create a composite measure that ranged from as low as 1 (never or almost never involved) to a maximum of 16 (involved on a daily basis). The measure created was continuous and for the purposes of the current study the variable was categorised by applying cut-scores at 33% of the frequency distribution. The implication is that all scores ranging from 1 to 11 were coded as 0, "Seldom involved", scores between 12 and 15 were coded as 1, "Weekly involvement" and scores equal to 16, were coded as 3, "Daily involvement".

"Family socio-economic status is a composite measure created that includes questions on amenities in the household. The Chronbach alpha was 0.895, which indicates an excellent internal consistency among the variables used to create this measure. One can conclude that the following variables (computer, study desk, books, own room, Internet connection, own cellular phone, dictionary, electricity, running tap water, television, video player, CD player, radio, water flushed toilets, motor car, own bicycle, telephone and a fridge) form a reliable measure of family socio-economic status. Learners could obtain a score as low as zero, indicating that they had none of the listed resources, to a maximum of 18 which indicates that learners had access to all the listed resources in their home. For purposes of multilevel modelling this variable was categorised and scores between 0 and 10 were recoded as 0, “Low SES”, scores between 11 and 13 were recoded as 1, “Medium SES” and finally scores of 14 or more were coded as 2, “High SES”.

“School climate” has also been known to have an impact on learner performance (Tschannen-Moran, Parish, & DiPaola, 2006) in the sense that a positive climate relates to an improvement in learner performance and vice versa in the case of a negative school climate.

Learner perception of school climate was derived using three statements that learners had to respond to and the answer options were based on a Likert scale ranging from 1, “Disagree a lot” to 4, “Agree a lot”. The statements learners responded to are the following:

- I like being at school;
- I feel safe when I am at school;
- I feel like I belong at the school.

The reliability analysis provided a Chronbach alpha of 0.626, indicating that the internal consistency among the three statements is acceptable. Responses to the three statements were then added together to create the composite measure that ranged from 1, “Disagree” to 12, “Agree”. For modelling purposes the measure was categorised where learners with a score lower than or equal to nine were coded as 0, “Unacceptable school climate”, scores between 10 and 11 were coded as 1, “Acceptable school climate” and finally scores equal to 12 were coded as 2, “Very good school climate”.

Finally the last category of variables used is TIMSS indices created by the International TIMSS study centre and that can be obtained directly from the data.

The scale method was used to create the scales because all items in the questionnaires that were used to create the scale made use of a Likert scale format. The index was created by averaging the values of the response options and then assigning the scale to three levels based on cut-off points.

The first TIMSS index included is home educational resources that include four variables that ask learners information pertaining to the number of books in the home, number of home study supports and lastly the highest level of education of either parent. This scale was categorised into three where learners with *many resources* had a score of at least 12.5, indicating that they had more than 100 books in the home and either of their parents had a university degree or higher and learners had access to the Internet in the home as well as their own room. Those with *few resources* with a score of no more than 8.2 on the other hand, had fewer than 25 books in the home, had neither their own room nor access to the Internet and either one parent completed secondary school at most. It stands to reason that learners with a score between 8.2 and 12.5 had *some of the resources,* indicating between 26 and 100 books, had either their own room or access to the Internet and parents completed a post-secondary education but not a university degree (see Table 3.3).

Table 3.3: Home educational resources scale

Category	**Number of books**	**Parent Education**	**Internet at home**	**Own room**
Many resources (score > 12.5)	> 100 books	University degree or higher	Yes	Yes
Few resources (score between 8.2 and 12.5	26 – 100 books	Post-secondary school but not university	Yes/No	Yes/No
Some resources (score less than 8.2)	< 26 books	Secondary education	No	No

Another scale created by the TIMSS centre was that of "Learner likes Maths" and is composed of six variables with response options on a Likert scale ranging from "Agree a lot" to "Disagree a lot". For modelling purposes the variable was categorised with scores greater than 11.3 as learners who “do not like learning Mathematics”; scores lower than 9 defined learners “who like learning Mathematics” and finally learners with scores between 9 and 11.3 were categorised as learners who “somewhat like Mathematics”. The following variables are included in this construct:

- I enjoy learning Maths;
- I wish I did not have to study Maths;
- Maths is boring;
- I learn many interesting things in Maths;
- I like Maths.

Six statements were included to create a measure called “Learners who value Mathematics” measured on a Likert scale ranging from “Agree a lot” to “Agree a little”. The measure was categorised into three where learners who *did not value* Mathematics obtained a score of at least 10.3, indicating that they either agreed a lot or a little. Learners who *value* Mathematics scored at most 7.9 and the learners with scores between 7.9 and 10.3 *somewhat value* Mathematics.

“Learners who value Mathematics” is a construct created using the following six variables from the learner questionnaire:

- It is important to do well in Maths;
- Learning Maths will help me in my daily life;
- I need Maths to learn other school subjects;
- I need to do well in Maths to get into the university of my choice;
- I need to do well in Maths to get the job I want;
- I would like a job that involves using Maths.

The last scale used for the analysis at a learner level and that was created by the TIMSS international study centre is that of “learners’ confidence in learning Mathematics”. The responses to the nine statements pertaining to learner confidence are on a Likert scale and range from 1 “Agree a lot” to 4 “Disagree a lot”, the following variables were used to create the scale:

- I usually do well in Maths;
- Maths is more difficult for me than for many of my classmates;
- Maths is not one of my strengths;
- I learn things quickly in Maths;
- Maths makes me confused and nervous;
- I am good at working out difficult Maths problems;
- My teacher thinks I can do well in Maths;
- My teacher tells me I am good at Maths;
- Maths is harder for me than any other subjects.

The variable was categorised, scores greater than or equal to 12 were coded as "learners who are not confident" and values smaller than 9.4 were learners who said they were "confident in learning Mathematics"; finally scores between 9.4 and 12 were coded as learners who are "somewhat confident in learning Mathematics".

3.6.4.2 School factors

Details of the variables selected at school level are listed in Table 3.4 with some variables taken directly from the school/principal questionnaire (which may have been recoded or kept in their original form), TIMSS created indices as well as one composite measure. This section provides some background to the composite measure (school SES) created as well as the international TIMSS indices that form part of this study.

Table 3.4: Level-2 (school level variables)

Value		Response option codes	Label
Class size	Directly from the questionnaire	1	Fewer than 30 learners (Sz_l30)
		0	Otherwise
		1	31 to 40 learners (Sz_31_40)
		0	Otherwise
		1	41 plus learners (Sz_41plus)
		0	Otherwise
Assess (ASSESS)	Directly from the questionnaire	0	Monthly or less frequently
		1	At least every two weeks
Teachers' perception of school climate (TEACH_CLIM)	Composite measure		Continuous variable
Resources (Sch_Res)	TIMSS indicator	0	Poorly resourced
		1	Somewhat resourced
		2	Well resourced
Maths specialisation (Mathspec)	Directly from the questionnaire	0	No Maths major
		1	Maths major
Teacher experience (TeachExp)	Directly from the questionnaire	0	1 to 5 years
		1	6 to 14 years
		2	15 to 19 years
		3	20 or more years
Teacher level of education (Educ_Level)	Directly from the questionnaire	0	Matriculation or Post-Matriculation Certificate
		1	Finished diploma
		2	Finished first degree
		3	Finished honours degree or higher
Resources shortages (BCDGMRS)	TIMSS indices	0	Affected a lot
		1	Somewhat affected
		2	Not affected

Teacher working conditions (BTDGTWC)	TIMSS indices	0	Serious problems
		1	Minor problems
		2	Hardly any problems
School SES (SchSES)	Composite measure	0	Low status
		1	Medium status
		2	High status

The variable that asked teachers how often they did assessments originally consisted of four categories (about once a week, about every two weeks, about once a month and a few times a year). For the purposes of this study the assessment variable was recoded to create two categories, namely "at least twice a week" and "monthly or less frequently".

Teachers' perception of school climate included eight statements from the teacher questionnaire with response options (Likert scale) 1, "Very high"; 2, "High", 3, "Medium"; 4, "Low" and 5, "Very low". In order to create this measure the response options were recoded so that they were reduced to three response codes and not five as in the original variable. This measure was used as a continuous variable in HLM and ranged from 8 (unacceptable climate) to 24, which referred to schools having a positive or acceptable climate. Statements included in this construct are the following:

- Teachers' job satisfaction;
- Teachers' understanding of the schools' curricular goal;
- Teachers' degree of success in implementing the school's curriculum;
- Teachers' expectations of schools achievement;
- Parental support for learner achievement;
- Parental involvement in school activities;
- Learners' regard for school property;
- Learners' desire to do well in school.

Teachers were given a list of options and asked what their major area of specialisation was while studying. Mathematics performance was the focus of the analysis in this study, hence it was important to know if teachers specialised in Mathematics or Mathematics education. This variable was recoded and a Mathematics specialisation variable was created to differentiate between teachers who are specialised and those who are not.

The TIMSS indicator "Shortages of instructional material" was composed of ten statements obtained from the principal questionnaire and responses range from 1, "Not at all"; 2, "A little"; 3, "Some" and 4, "A lot". The continuous measure was categorised with scores of more than 11 referring to schools that were "affected a lot by resources shortages"; scores lower than 7.3 were those schools "not affected by resource shortages" and the remainder were "somewhat affected by resource shortages". The following variables were included in this construct:

- Instructional material (textbooks);
- Budget for supplies (paper, pencils);
- School buildings and school grounds;
- Heating/cooling and lighting system;
- Instructional space (classrooms);
- Computers for Mathematics instruction;
- Computer software for Mathematics instruction;
- Calculators for Mathematics instruction;
- Library material relevant to Mathematics instruction;
- Audio-visual resources for Mathematics instruction.

"Teacher working conditions" is composed of three statements that were posed to teachers and on a Likert scale; the response options were 1, "Not a problem"; 2, "Minor problems"; 3, "Moderate problem" and 4, "Serious problem". This continuous measure was categorised so that schools with hardly any problems with the working condition obtained a score lower than 8.9 while schools with moderate problems obtained a score greater than or equal to 11.7. All schools with scores between 8.9 and 11.7 were categorised as schools with minor problems.

3.7 Data analysis

3.7.1 Data weighting

In order for the data to be representative of the population, weights were calculated, i.e. a weight was calculated for each learner, class and school. These weights were calculated taking the sampling design into account; in the South African data weights were calculated based on the strata information (i.e. province, school type and language of instruction and learning). The learner weight is a product of the sampling weight, the school weight as well as the class weight. In addition school and learner non-participation was also taken into consideration and factored into the learner weight. The sum of the weights equals the approximate number of learners in the population.

3.7.2 Descriptive analysis

Descriptive analysis on weighted data was done using SPSS to get an overview of all the variables used in this study. Descriptive statistics include general frequencies to obtain information on the spread of the selected variables. In addition univariate relationships were checked using ANOVA in the case of discrete variables and correlations for continuous variables. For discreet variables with more than two categories Bonferroni tests were done to establish if the groups within the variable are statistically different from one another.

Measures were developed to allow for a number of related variables to be reduced to a single measure/indicator defining a particular construct. For example, when creating the socio-economic status of the family the indicator was calculated based on certain amenities found in the house.

3.7.3 Hierarchical linear modelling

Hierarchical Linear Modelling (HLM) is commonly used when analysing hierarchical or multi-level social science data. In education, for example, learners exist within hierarchical social structures that include classroom, grade level, school, school district, province and country. Learners are said to be nested within classrooms that are in turn nested within schools; schools are nested within school districts that are in turn nested within provinces. In the current study the learners form the first level in the hierarchy and the schools the unit of analysis at level-2. Similar to the assumptions that exist with ordinary least square analysis, HLM has assumptions that must be met before an analysis of this nature can be done.

3.7.3.1 HLM assumptions

- The expected outcome must be expressed as a linear function of the regression coefficients. This indicates that the dependent variable must be normally distributed. Non-normally distributed variables that are skewed and have large kurtosis with substantial outliers can distort relationships and significance tests; hence visual representation allows one to check for extreme outliers that may skew the results.
- The level-1 residuals are normally distributed with constant variance (homoscedasticity). The distribution can be checked visually using histograms and scatter plots.
- The level-2 residuals must be uncorrelated.
- Independence of observations at the highest level (level-1).

3.7.3.2 Basic 2-level HLM model

Formally there are i = 1,….. n_j level-1 units (e.g. learners) that are nested within each of the j = 1,… J level-2 units (e.g. schools).

Level-1 model:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1j} + \ldots + \beta_{Pj} X_{pj} + e_{ij}$$

Where:

β_{Pj} (p=0,1, … P) are level-1 coefficients;

X_{pj} is a level-1 predictor p for case i in level-2 unit J;

$e_{ij} \sim N(0,\sigma^2)$ normally distributed with mean zero and variance σ^2.

Level-2 model: Each of the β_{Pj} coefficients in the level-1 model becomes an outcome variable in the level-2 model:

$\beta_{0j} = \gamma_{00} + \gamma_{01} Gj + \mu_{0j} \qquad \mu_{0j} \sim N(0, \tau_{00})$

$\beta_{1j} = \gamma_{10} + \gamma_{11} Gj + \mu_{1j}$

Where:

β_{0j} is the intercept for the j^{th} level-2 unit;

β_{1j} is the slope for the j^{th} level-2 unit;

Gj is the value on the level-2 predictor;

γ_{00} is the overall mean intercept adjusted for G;

γ_{10} is the regression coefficient associated with level-1 intercept;

μ_{0j} is the random effects of the j^{th} level-2 unit on the intercept;

μ_{1j} is the random effects of the j^{th} level-2 unit on the slope.

3.7.3.3 Models used in the current study

In this study 25 models were constructed in an attempt to determine the factors at learner (level-1) (see Table 3.5) and school (level-2) (see Table 3.6) level that are associated with performance. The analysis begins with the unconditional model commonly referred to as the Base Model (model 1). This model has no predictor (independent) variables and is used to identify the amount of variance explained between schools so that when predictor variables are added it is hoped that the variance between schools is reduced. Level-1 predictors are then added individually (models 2 to 13) and all significant variables are included in model 14 which will become the final level-1 model. Level-2 variables in a similar fashion to level-1 model building were added to model 14 and models 15 to 25 were developed. The regression equations for models 1 to 25 are as follows:

$Y_{0j} = \beta_{00} + \beta_{0j*} x + r_{0j}$

$\beta_{0j} = \gamma_{00} + \mu_{0j}$

Where Y_{0j} is Mathematics score of learner i in school j;

β_{00} is the regression intercept for school j;

γ_{00} is the overall Mathematics score for all schools;

μ_{0j} is the random effect of school j;

r_{0j} is the random effect of learner i in school j.

Table 3.5: Level-1 models with variable labels as used in analysis

Model 1:	Y_0j = MathsScore (BSMMAT01-BSMMAT05)= $\beta_{00} + \beta_{0j*}$ x + r_{0j}
Model 2:	$Y_0j = B_0j + B1*(Age10\_13) + B_2*(Age17PLU) + rij$
Model 3:	$Y_{0j} = \beta_{0j} + \beta_{1j}African_{ij} + r_{ij}$
Model 4:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,LoLt_{ij} + r_{ij}$
Model 5:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,Nuclear_{ij} + r_{ij}$
Model 6:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,SEScat_{ij} + r_{ij}$
Model 7:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,AdultInvcat_{ij} + r_{ij}$
Model 8:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,SchClimcat_{ij} + r_{ij}$
Model 9:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,HMEEdRes_{ij} + r_{ij}$
Model 10:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,Bully_{ij} + r_{ij}$
Model 11:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,LikeMath_{ij} + r_{ij}$
Model 12:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,ValMath_{ij} + r_{ij}$
Model 13:	$Y_{0j} = \beta_{0j} + \beta_{1j}\,ConfMath_{ij} + r_{ij}$
Model 14:	$Y_{0j} = \beta_{0j} + + \beta_{1j}*(AGE17PLU) + \beta_{2j}\,AdultInvcat_{ij} + \beta_{3j}\,Bully_{ij} + \beta_{4j}\,LikeMath_{ij} + \beta_{5j}\,ValMath_{ij} + \beta_{6j}\,ConfMath_{ij} + r_{ij}$

Similarly, at level-2 (see Table 3.6) all the school level variables were added one at a time with the difference now being that the final level-1 model (model 14) was used and not the unconditional model as before. Models 15 and 16 are in response to research question 2 pertaining to classroom factors and models 17 to 25 refer to the school factors that respond to the third research question.

Table 3.6: Level-2 HLM models with variable labels as used in analysis

Model 15:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ Assess + μ_{pj}
Model 16:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ Teach_Clim + μ_{pj}
Model 17:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ SchSES + μ_{pj}
Model 18:	$\beta_{0} = \gamma_{p0} + \gamma_{p1}$ (SZ_L30) + γ_{p2} (SZ41PLUS) + μ_{pj}
Model 19:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ Sch_Res + μ_{pj}
Model 20:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ TeachExp + μ_{pj}
Model 21:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ Mathspec + μ_{pj}
Model 22:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ Educ_Level+ μ_{pj}
Model 23:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ BCDGMRS + μ_{pj}
Model 24:	β pj = γp0+ γp1 BTDGTWC+ μ pj
Model 25:	$\beta_{pj} = \gamma_{p0} + \gamma_{p1}$ SchSES + γ_{p2} Sch_Res + γ_{p3} Mathspec + γ_{p4} BTDGTWC + μ_{pj}

3.8 Summary

This chapter provides the details of the research design and methodology utilised in this study. Details of the conceptual framework have been discussed in terms of the three paradigms generally referred to in educational research. The research process of the study has been explained within the scope and assumptions of the post-positivist paradigm. An outline of the sample, instruments used, research questions, hypotheses as well as the method of data analysis has been provided. In the next chapter data is analysed and interpreted.

Chapter 4

4 Data Analysis and findings

4.1 Introduction

This study is based on secondary data analysis and the intended purpose is to explore the influence of school and family factors as they relate to educational quality.

The results are described descriptively using frequency tables, graphs, simple analysis of variance (ANOVA) and correlations where applicable. Since parametric methods have been utilised the assumption of normality of all variables are tested graphically using histograms and appropriate tests.

The relationships between Mathematics performance and the independent variables are tested by ANOVAs in the case of discrete independent variables, and correlations in the case of continuous independent variables.

The effect that the selected variables have on learner outcomes is analysed using Hierarchical Linear Models (HLM). Given the hierarchical nature of educational data (learners nested in schools), HLM is particularly suitable for the analysis demands of this thesis. As stated by Raudenbush and Bryk (2001) the major functions of HLM are the following:

- To improve individual units' estimation effects.
- To formulate and test hypotheses about across-level effects.
- To partition variance-covariance components among levels.

Although the data for this study potentially have three levels – learners (level 1), classrooms (level 2) and schools (level 3), the analysis utilises a 2-level HLM that measures differences between learners within schools as well as differences between schools. Only one classroom per school was selected for data collection and therefore it is impossible to carry out a three-level HLM analysis.

The initial analysis involves descriptive and exploration of the learner level data followed by the school effect assessment employing HLM.

4.2 Descriptive analysis

From a population of 9 419 Grade 9 schools in South Africa a sample of 298 was selected to form part of the TIMSS 2011 study. A total of 285 schools were realised providing a realisation rate of 95.6%. Since a single intact class was selected in every school and with a maximum of possible 40 learners per class, it was estimated that the total number of learners in the sample would be around 12000. The scores and background information of 11 969 learners were realised from a population of approximately 953 284 Grade 9 learners in the country. A provincial breakdown of the sample is provided in Chapter 3, Table 3.1.

This section of the chapter provides the distribution of selected variables at the learner level by using descriptive statistics and graphical displays.

4.2.1 Mathematics performance as the dependent variable

As mentioned before Mathematics performance is used as a measure of educational quality and for this study it is the dependent variable, which is a continuous variable and measured as a score out of 1 000.

The mean Mathematics score is 352 out of a possible 1000 (see Table 4.2) which is far below the international centre point of 500. Five international benchmarks were created by the International Study Centre in Germany to assist countries to do comparisons between countries as well as within countries. Table 4.1 shows the percentages in the international benchmarks and it is clear that the majority (76%) of learners fall in the "below 400" category with only 24% obtaining scores greater than 400 and only 6% obtaining scores above the international centre point of 500.

Table 4.1: International benchmark percentages

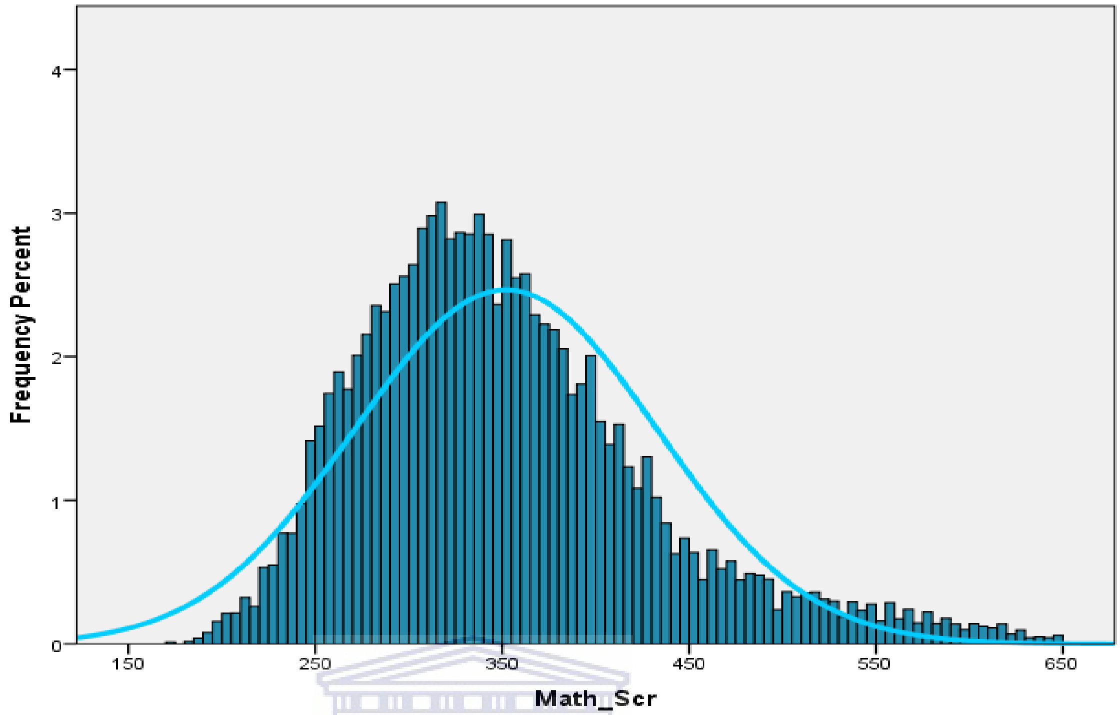
Benchmark	% of learners
Below 400	76
From 400 to below 475	16
From 475 to below 500	2
From 500 to below 550	3
From 550 to below 625	2
At or above 625	1

The scores range from 170.4 to 746.05 resulting in a range of 575.6 (see Table 4.2), which shows large variation between the Mathematics scores of the poor performing learners and those of the well performing learners. Seventy-five percent of learners fall within the interquartile range of 97.08 (see Table 4.2) and obtained scores of between 293 and 398. The histogram (see Figure 4.1) shows that the data is approximately normal; hence parametric analysis is used.

Table 4.2: Mathematics Descriptive Statistics

Mathematics Performance	Statistic
Mean	351.94
Median	339.61
Std. Deviation	80.87
Minimum	170.41
Maximum	746.05
Range	575.64
Interquartile Range	97.08
5th percentile (2.4% of learners)	229
25th percentile (21.5% of learners)	293
50th percentile (28.2% of learners)	343
75th percentile (24.8% of learners)	398
95th percentile (23.1% of learners)	516

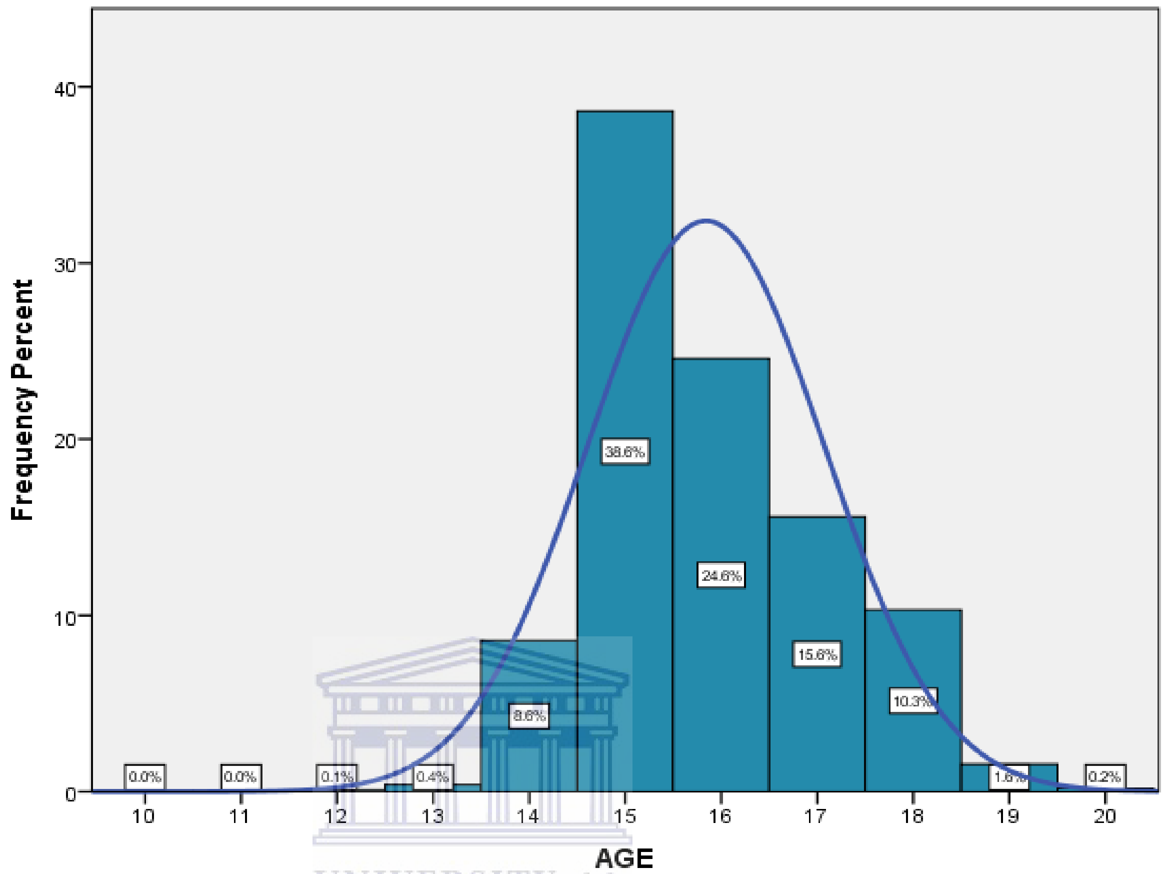
Figure 4.1: Distribution of Mathematics scores (dependent variable)



4.2.2 Learner Level

The age of the majority of the learners falls in the range 14 to 16 years (72%), which is the approximate age of a learner at the Grade 9 level. If a learner started Grade 1 at the age of seven and did not repeat any grades the learner will be 15 years old in the ninth year (Grade 9) of schooling. In Figure 4.2 only 39% of the learners are of the appropriate age. An alarming 53% (see Figure 4.2) of the Grade 9 learners are 16 years and older, which could be indicative of grade repetition or starting school later than expected. From Figure 4.2 age appears approximately normally distributed although it is expected that many learners should be approximately the same age as they are in the same grade.

Figure 4.2: Distribution of learner age



When looking at the population group of the learners in the study it is observed that 75.9% are African (see Table 4.4) and the remaining 24.1% make up the remaining racial groups (White (9%), Coloured (10.8%), Indian (1.6%) and other (2.7%) as seen in Table 4.3. For purposes of the multilevel modelling this variable is dichotomised where the comparison is between African and everyone else.

Table 4.3: Population group before recode into dichotomy

Population Group	**n**	**Percentage (%)**
African	8749	75.9
Coloured	1242	10.8
Indian/Asian	189	1.6
White	1041	9.0
Other	310	2.7
Total	**11531**	**100.0**

Table 4.4: Frequency distribution of race

Population Group	n	Percentage (%)
Other	2782	24.1
African	8749	75.9
Total	**11531**	**100.0**

An important variable to consider in the education arena is that of the home language of the learner and the language of instruction and its effect on learning outcomes. The schools sampled in TIMSS offered English, Afrikaans or both as language of instruction and similarly TIMSS learners were tested in these languages. When looking at the distribution of home language it is observed (see Figure 4.3) that the majority of learners speak isiZulu (26%) at home. This is followed by isiXhosa (18%) and then Sepedi (12%), with only 17% speaking either English or Afrikaans. What is clear from Figure 4.3 is that the majority of learners speak one of the nine African languages (83%) at home and yet are taught in either English or Afrikaans, which is spoken in only 17% of the homes on average (see Figure 4.3).

Stemming from this a variable was created that checks whether the language of instruction (the language the learner is taught in at school) is the same as the language mostly spoken at home. This is a dichotomised variable that shows that in 86% of the cases learners are taught in a language that is not their home language (see Figure 4.4). The dichotomised variable is included in the multilevel analysis.

Figure 4.3: Distribution of language spoken mostly at home

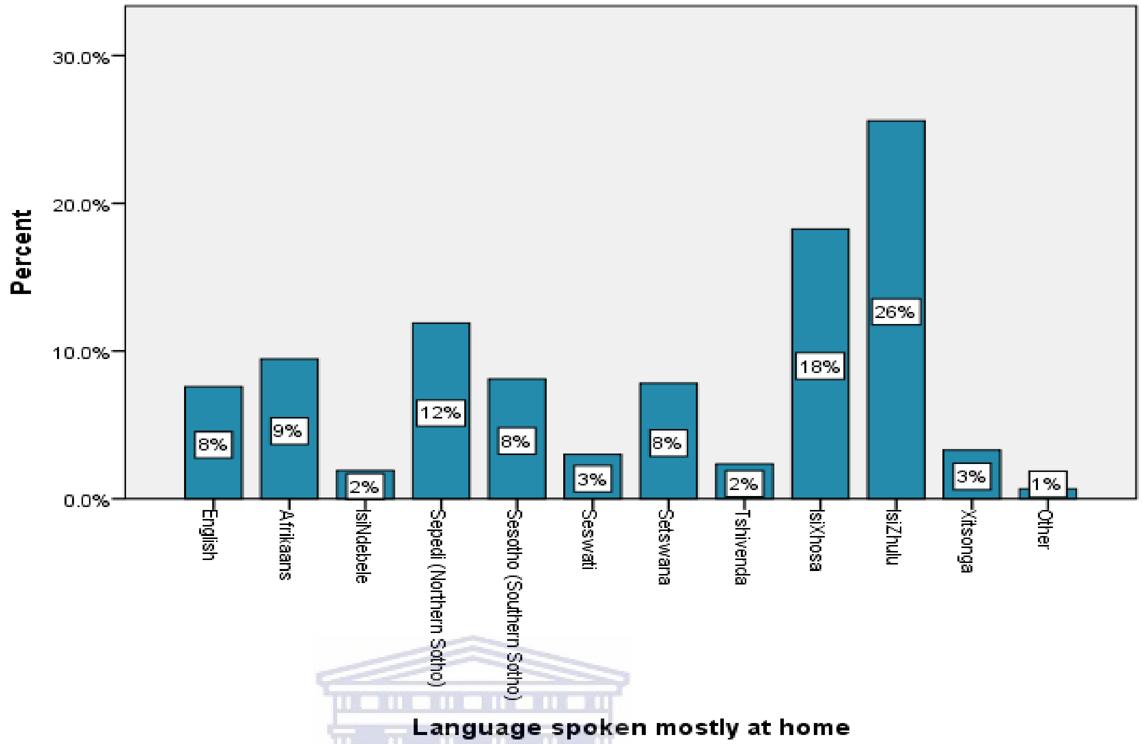
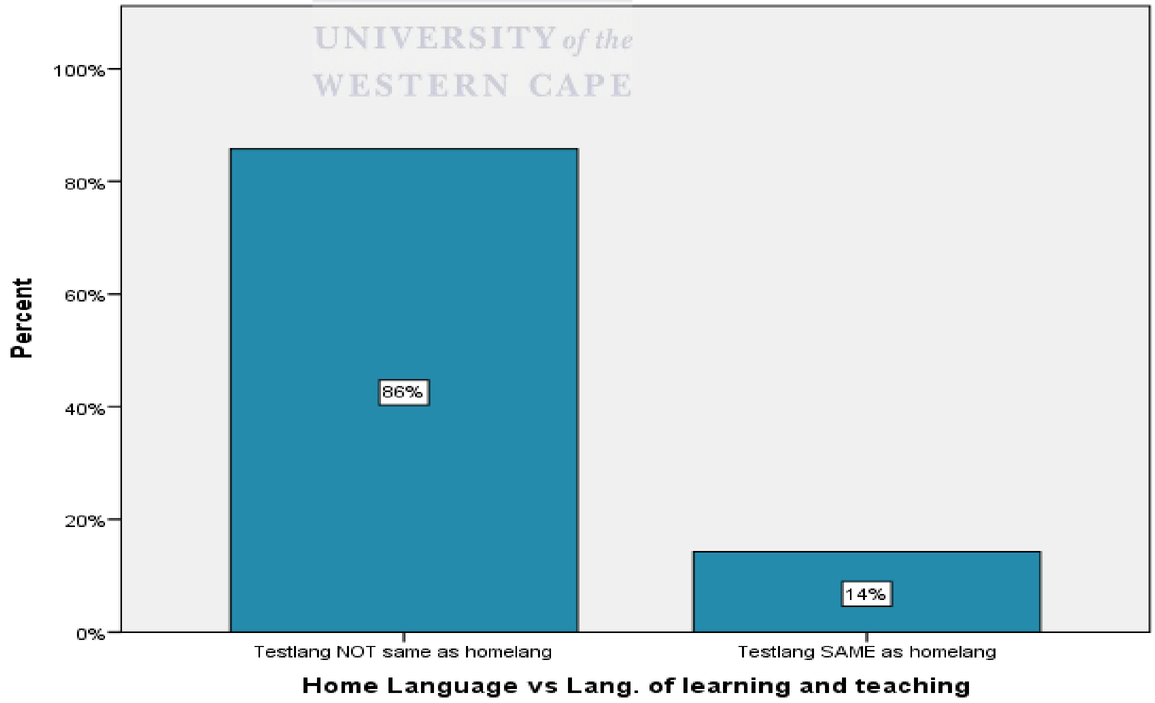
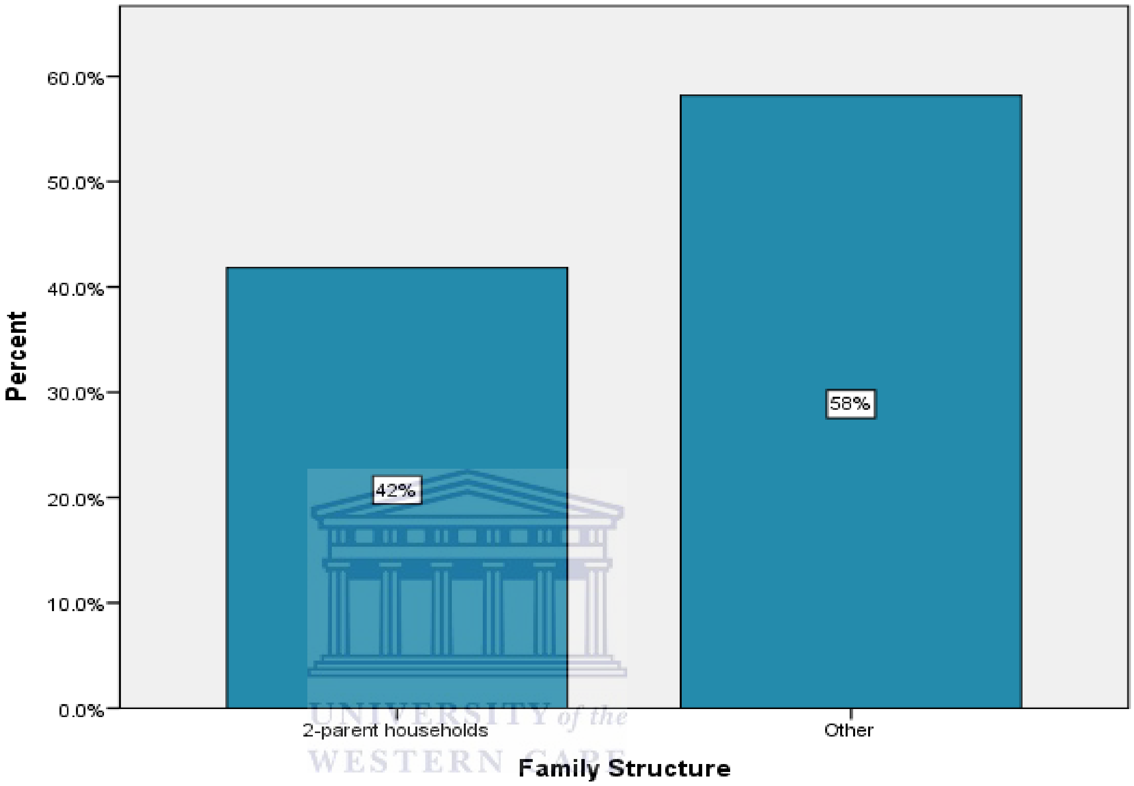


Figure 4.4: Comparison between home language and language of instruction



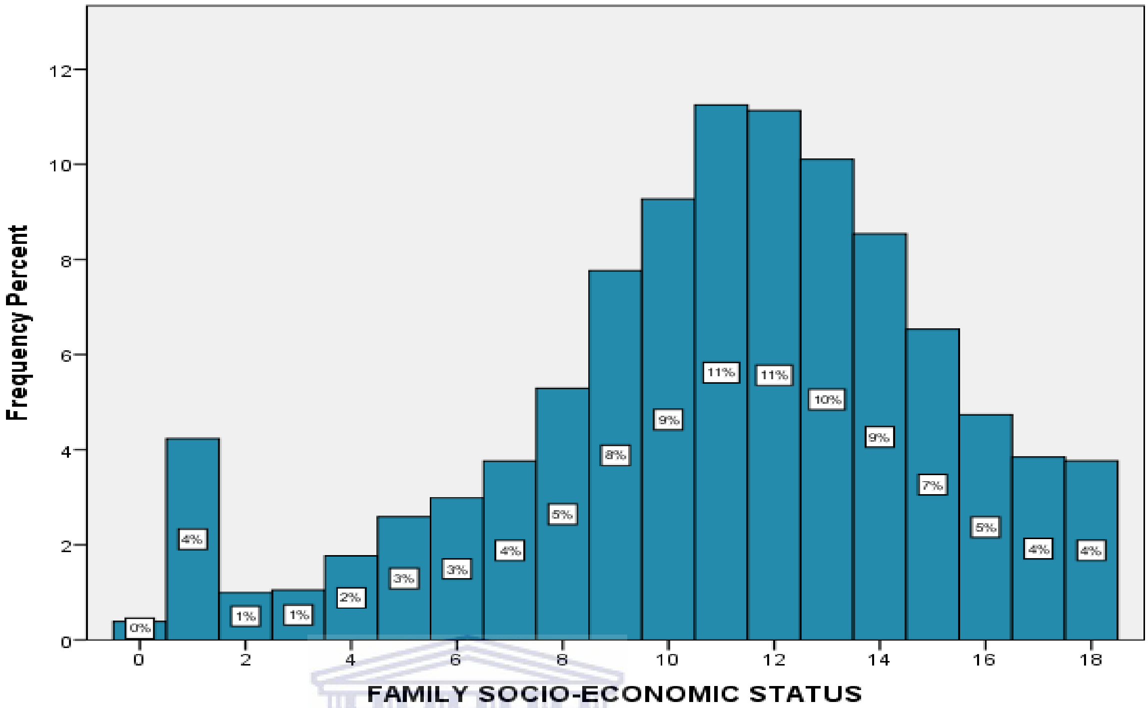
The details of the family structure variables are provided in Chapter 3. Figure 4.5 shows that 42% of learners come from families that have two parents compared to the 58% of learners who belong to households that do not have two parents. These could be children living with single parents, grandparents, aunts or uncles.

Figure 4.5: Percentage of learners in each of the 2-parent family structure categories



Family socio-economic status (SES) is a composite measure created to evaluate the wealth of a family (details provided in Chapter 3). Family SES ranges from 0 (learners have none of the listed items in their homes) to 18, indicating that learners have all the listed resources in the home. Figure 4.6 shows that the variable is reasonably normally distributed with 29% of learners having 14 or more of the listed items in their homes. Figure 4.6 shows that 31% of the learners have nine or fewer of the listed items and 40% have between 10 and 13 of the items included in the scale.

Figure 4.6: Distribution of family socio-economic status



For purposes of modelling this continuous variable has been categorised into low, medium and high SES levels (details provided in Chapter 3, Section 3.6.4.1). Figure 4.7 shows that the majority (40%) of learners come from low SES households; 32% from medium SES and only 27% from high SES households.

Figure 4.7: Socio-economic status categorised

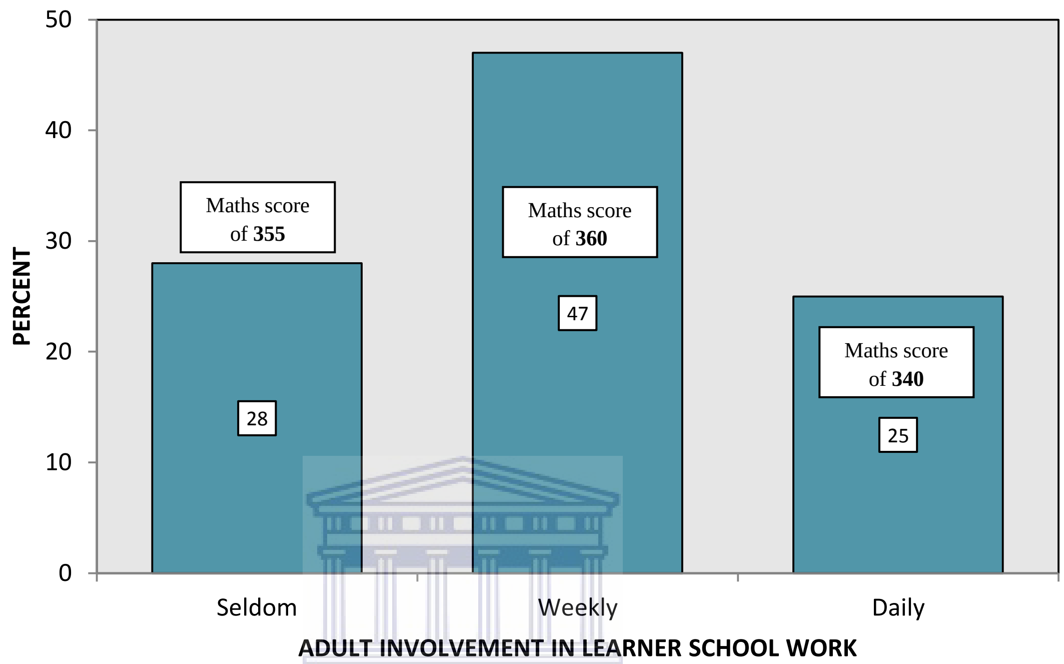
Chapter 3 provides the details pertaining to the composite measure created for parental/adult involvement in issues pertaining to the learners' homework. Table 4.5 provides percentages of learner responses to each question included in the adult involvement scale. Across all the questions included in the scale, more than 50% of the learners said their parents were involved in their school work on a daily basis with the highest percentage being parents who make sure that time is set aside for homework (66.3%). However, interesting to note is that in 13.4% of the cases learners reported that their parents never or almost never checked their homework.

Table 4.5: Percentage per response on question used to create parental involvement scale

	Never or almost never (%)	Once or twice a month (%)	Once or twice a week (%)	Every day or almost every day (%)	Total
My parents ask me about what I learn at school	5.8	8.9	23.8	61.4	100
I talk about my school work with my parents	5.9	9.7	30.4	54.0	100
My parents make sure that I set aside time for my homework	8.2	7.4	18.1	66.3	100
My parents check if I do my homework	13.4	9.2	23.0	54.3	100

For statistical modelling purposes the parental involvement variable has been categorised (refer to Chapter 3, Section 3.6.4.1 for details) into parents who are seldom involved (28%), parents involved on a weekly basis (47%) and parents involved on a daily basis (25%) (see Figure 4.8). Interesting to note however, is that learners whose parents are involved in their homework on a weekly basis seem to score more (360) on average than learners whose parents are involved on a daily basis (340). The data shows that parents who are seldom involved score on average higher (355) than learners who whose parents are involved on a daily basis (see Figure 4.8).

Figure 4.8: Adult involvement in learners' school work and average mathematics score.



The school climate composite measure consists of three statements with response categories ranging from 1 (Agree a lot) to 4 (Disagree a lot) as in Table 4.6 (refer to Chapter 3 for details). Most learners like being at school (75.9%) followed by 60.4% of learners who said they felt safe at the school and 56.8% felt a sense of belonging.

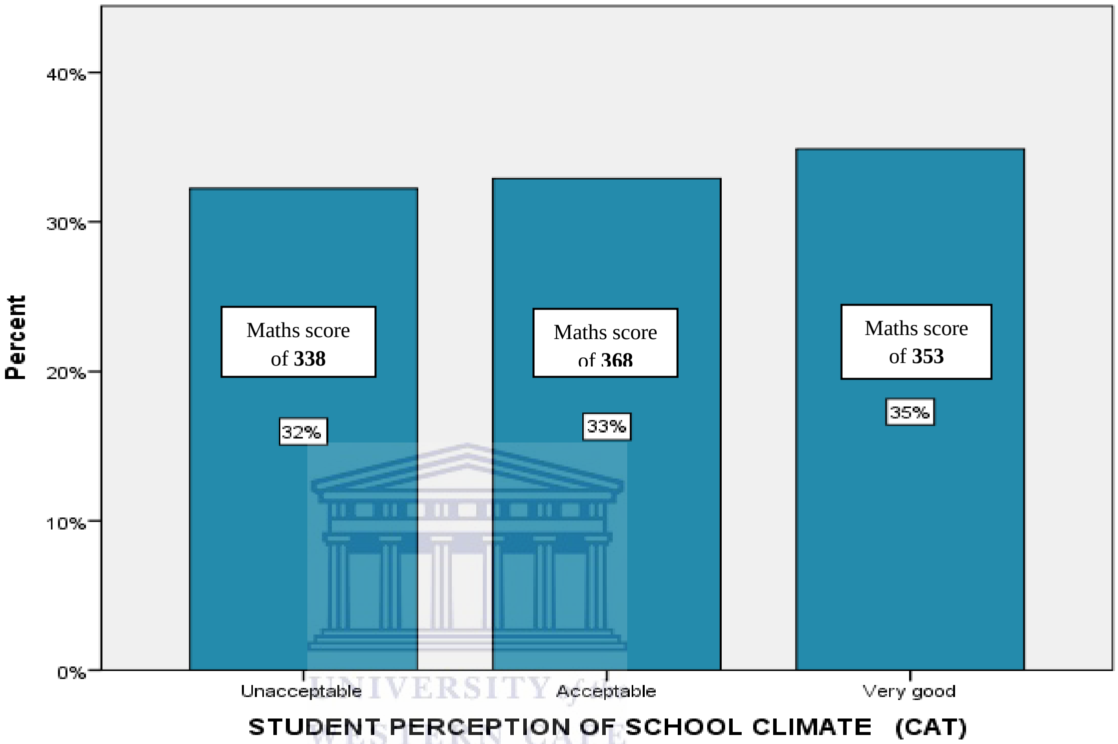
Table 4.6: Statements of school climate measure

	Agree a lot	**Agree a little**	**Disagree a little**	**Disagree a lot**	**Total**
I like being at school	75.9	17.4	4.1	2.6	100
I feel safe when I am at school	60.4	27.1	7.3	5.2	100
I feel as if I belong at the school	56.8	25.9	10.7	6.6	100

Figure 4.9 shows that learners who reported the climate at the school to be very good obtained higher Mathematics scores on average (353) than those who said

the climate was unacceptable (338). Interesting to note is that learners who said the climate was just acceptable scored slightly higher (368) than those who perceived the climate to be very good.

Figure 4.9: Student perception of school climate and average Mathematics scores



Five questions that were asked of learners are included in the bullying scale (Refer to Chapter 3 for details) and range from 1 (At least once a week) to 3 (Almost never) and percentages of responses per question and per response category are shown in Table 4.7.

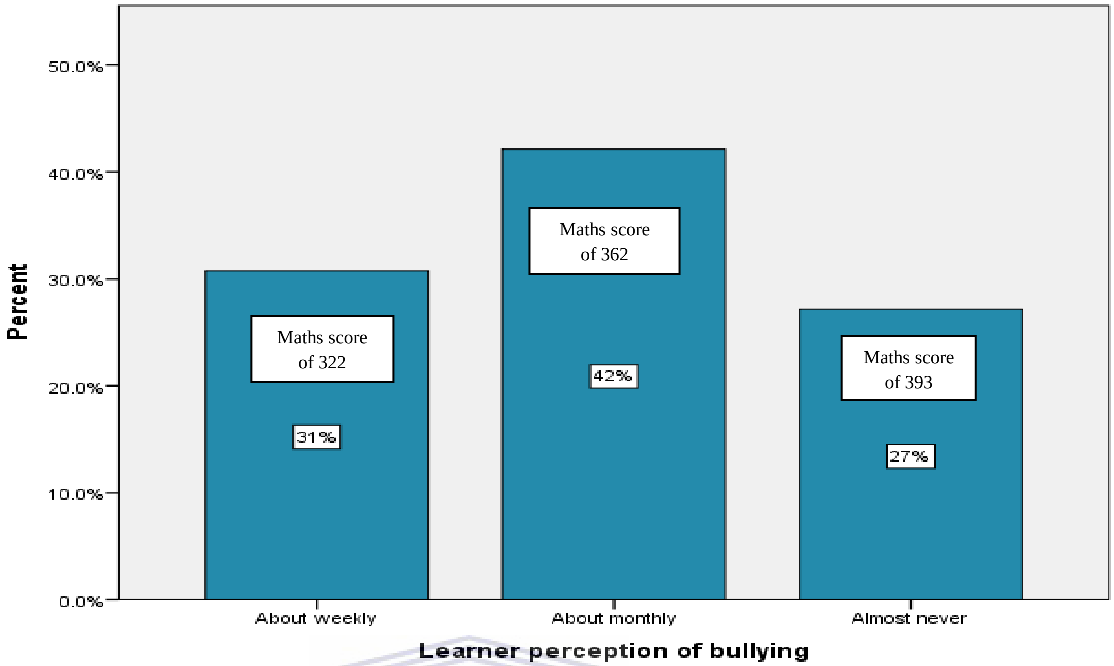
More than 70% of learners said that they were not hit or hurt or made to do things that they did not want to, which are the highest percentages across the questions where learners responded almost never being bullied. From the data the factors that learners are least affected by are issues of being physically harmed (77.3%) at school, being forced to do things they did not want to do (74.4%), being left out of games (64.1%) and lies being spread about them (62.3%). However, problems that still arise at least once a week are issues like theft (27%) and name calling (31.5%).

Table 4.7: Percentage per response on question used to create the bullying scale

Statement	At least once a week	Once or twice a month	Almost never	Total
I was made fun of or called names	31.5	17.9	50.6	100
I was left out of games and activities by other learners	18.0	17.9	64.1	100
Someone spread lies about me	18.0	19.8	62.3	100
Something was stolen from me	27.0	23.9	49.1	100
I was hit or hurt by other learners	10.8	11.8	77.3	100
I was made to do things I did not want to do by other learners	14.2	11.3	74.4	100

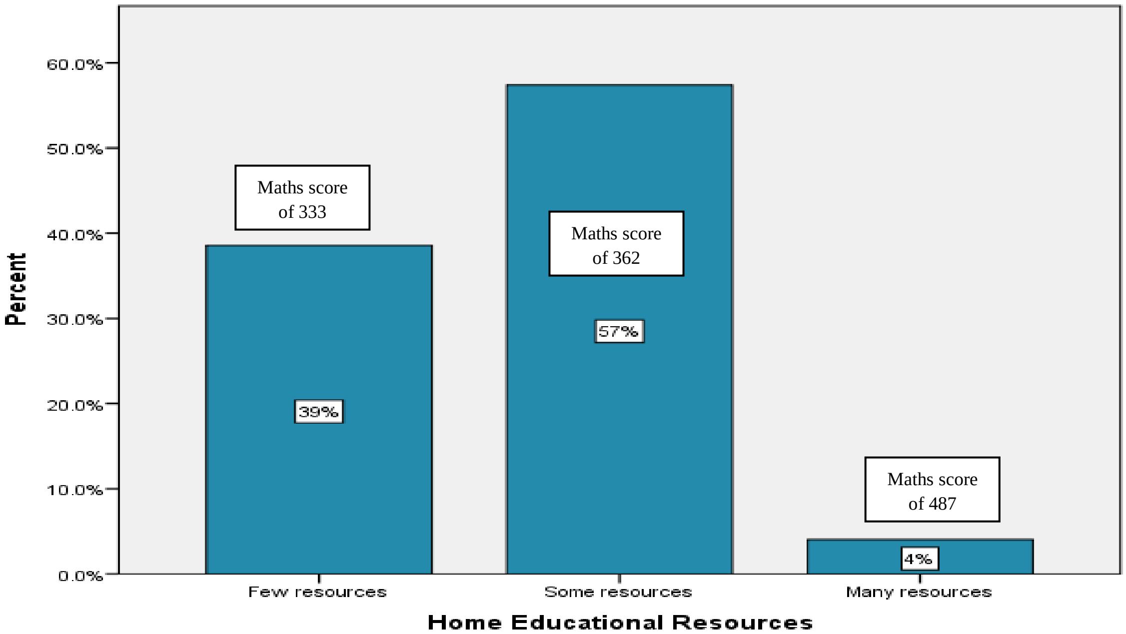
There seems to be a relationship between learners who are bullied and Mathematics performance. This is evident from Figure 4.10 that shows learners who are never bullied obtain higher Mathematics scores on average (393) than those who are being bullied on a weekly basis (322). The achievement gap is greatest between learners who are almost never/never bullied and those who are bullied on a weekly basis (71 points). However, this gap decreases to 31 points when comparing learners who have never been bullied and those who are bullied once or twice a month.

Figure 4.10: Learner perception of being bullied at school and Mathematics average



The home educational resources composite measure refers to parental education, number of books in the home as well as whether the learner has his/her own room and access to a computer at home (Refer to Chapter 3, Section 3.6.4.1 for the details). Figure 4.11 shows that only 4% of learners have access to all the listed items in their home as compared to the 39% who have only a few resources. The data indicates that many have fewer than 26 books in the home, no Internet access, do not have their own room and either parent has a secondary school qualification. Most learners have access to some of the resources (57%) in their home (26 to 100 books, either own room or internet access or have a parent with a post-secondary qualification but not a university degree). Learners categorised as having many resources scored on average 487 points which is 154 points higher than learners who have few resources (333) and 125 points more than learners who have some resources (362).

Figure 4.11: Home educational resources index with Mathematics average



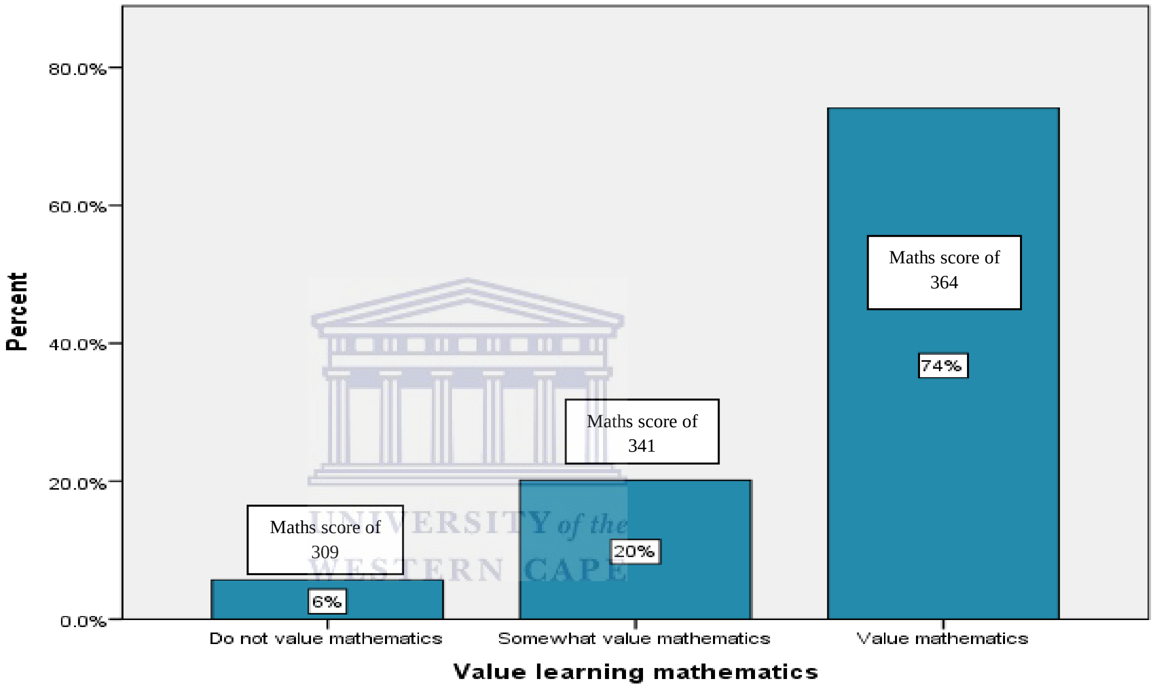
A composite measure was created to determine whether learners value Mathematics; Table 4.8 provides the list of variables included in the measure. Learners strongly agree that it is important to do well in Mathematics (84%) and that it will help in their daily lives (82%). Learners feel that it is important to do well so that they can get into university (80%) and also to get the job they want (77%). Interesting to note is that even though learners feel they need Mathematics to get a good job only 48% want their jobs to include using Mathematics (see Table 4.8).

Table 4.8: Variables used to create the index of whether learners value Mathematics

	Agree a lot	Agree a little	Disagree a little	Disagree a lot	Total
It is important to do well in Maths	84	9	4	3	100
Learning Maths will help me in my daily life	82	12	3	3	100
I need Maths to learn other school subjects	59	28	8	5	100
I need to do well in Maths to get into the university of my choice	80	12	5	3	100
I need to do well in Maths to get the job I want	77	14	5	4	100
I would like a job that involves using Maths	48	29	12	11	100

An overwhelming 74% (see Figure 4.12) of learners said they value Mathematics and it is clear these learners also have a higher average Mathematics score (364) than the 6% of learners who said they do not value Mathematics (309). Even those learners who said they somewhat value Mathematics (20%) had an average score of 341 which is higher than the average score obtained by those learners who said they did not value mathematics.

Figure 4.12: Learners value Mathematics index and Mathematics average



The composite measure for learners liking Mathematics was created using five statements from the learner questionnaire (refer to Chapter 3, Section 3.6.4.1 for the details). More than 55% of learners agreed that they liked and enjoyed Mathematics and also found it interesting. About half of learners said they found Mathematics boring and wished they did not have to study Mathematics (44.5%), (see Table 4.9).

Table 4.9: Variables used to create the index of learners who like learning Mathematics

	Agree a lot	Agree a little	Disagree a little	Disagree a lot	Total
I enjoy learning Maths	59.6	28.1	6.9	5.4	100
I wish I did not have to study Maths	16.8	22.4	16.3	44.5	100
Maths is boring	11.8	18.3	19.9	50.1	100
I learn many interesting things in Maths	58.5	25.9	9.8	5.8	100
I like Maths	57.7	25.8	8.8	7.7	100

Figure 4.13 shows that 41% of learners said they liked learning Mathematics and scored an average of 378 which is higher than the 16% of learners who said they did not like learning Mathematics (348). Interesting to note is that the learners who said they did not like learning Mathematics had a Mathematics score slightly higher (348) than those learners who said they somewhat liked learning (339) Mathematics.

Figure 4.13: Learners who like learning Mathematics and Mathematics average

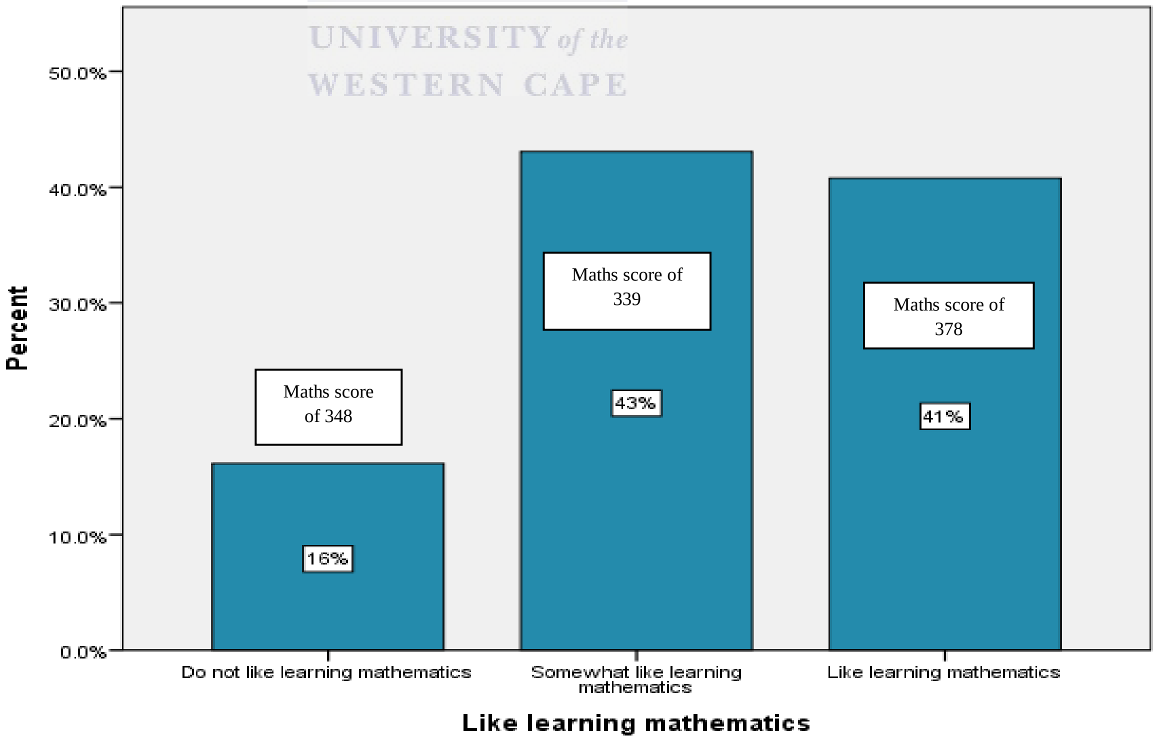


Table 4.10 shows across most of the statements included in this measure more agreed a little than those who agreed a lot. Specifically 45.1% of learners agreed a little that they usually did well in Mathematics compared to the 35.9% who said they agreed a lot. Almost 40% of learners said that they agreed a little with the statement that they are good at working of difficult problems. Looking at the statement that asks the learner whether they feel Mathematics is one their strengths, Table 4.10 shows that 54% agreed either a little or a lot compared to the 46% that disagreed a little or a lot with the same statement. This is a slight contradiction when looking at the statement that asks learner whether they learn things quickly in Mathematics with almost 73% saying that they agree a little or a lot with this statement. One would expect that a learner who learns Mathematics quickly would also say that it is one of their strengths.

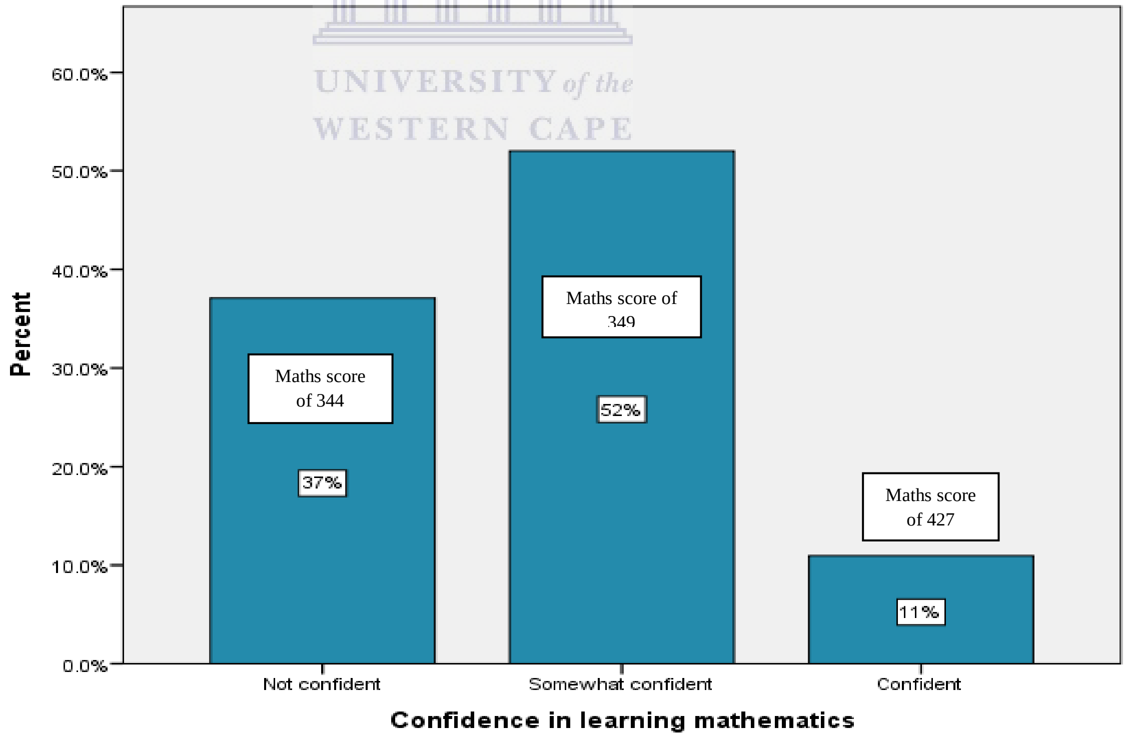
Table 4.10: Responses to the index of learners who are confident in learning Mathematics

	Agree a lot	Agree a little	Disagree a little	Disagree a lot	Total
I usually do well in Mathematics	35.9	45.1	13.0	6.0	100
Maths is more difficult for me than for many if my classmates	23.0	35.4	21.3	20.2	100
Maths is not one of my strengths	23.8	30.2	19.2	26.9	100
I learn things quickly in Maths	35.6	36.6	18.7	9.1	100
Maths makes me confused and nervous	21.5	29.4	20.7	28.3	100
I am good at working out difficult Maths problems	25.8	38.7	21.6	14.0	100
My teacher thinks I can do well in Maths	36.7	35.6	17.9	9.7	100
My teacher tells me I am good at Maths	28.0	34.3	20.6	17.1	100
Maths is harder for me than any other subjects	30.6	28.3	17.8	23.2	100

The majority of learners (52%) seem somewhat confident in learning Mathematics, followed by 37% (see Figure 4.14) who are not confident at all. Alarmingly only 11% of learners say they are confident in learning Mathematics. This seems to contradict the results from the previous two measures in that 74% of learners say they value Mathematics (See Figure 4.14), and 84% of learners say they like or somewhat liked learning Mathematics (see Figure 4.12); yet only 11% are confident in learning Mathematics.

Learners who are confident in learning Mathematics have a higher average Mathematics score (427) than those who are somewhat confident who have an average score of 349 (see Figure 4.14). Those who are not confident in learning Mathematics scored 344 on average. There is only a 5-point difference between learners who are somewhat confident and those who are not confident; however, there is an 83 point difference between learners who are confident and those who are not confident in learning Mathematics.

Figure 4.14: Learner confidence in learning Mathematics and Mathematics Average



4.2.3 Testing relationships between Mathematics performance and learner level (independent) variables

Table 4.11 provides an overview of the distribution of the variables, type of variables (discrete or continuous) as well as the type of analysis used to test if relationships exist between the Mathematics score (dependent) and the independent variables. In cases where independent variables are discrete simple ANOVAs are used and in the case of continuous independent variables, correlations are used.

Table 4.11: Outline of learner level variables included in the analysis

Learner level variables	**Distribution**	**Type of variable**	**Type of analysis**
Age	Normal	Continuous	Pearson correlation
Population group	Non-normal	Discrete (Nominal)	ANOVA
Language of learning and teaching (LoLT)	Non-normal	Discrete (Nominal)	ANOVA
Family structure	Non-normal	Discrete (Nominal)	ANOVA
Family SES	Normal	Continuous	Pearson correlation
Home educational resources	Non-Normal	Discrete (Nominal)	ANOVA
Adult involvement in student learning	Non-normal	Continuous	Spearman correlation
Learner being bullied	Non-Normal	Discrete (Nominal)	ANOVA
Learner perception of school climate	Non-normal	Continuous	Spearman correlation
Learner likes Mathematics	Non-Normal	Discrete (Nominal)	ANOVA
Learner values Mathematics	Non-Normal	Discrete (Nominal)	ANOVA
Learner confidence in learning Mathematics	Non-Normal	Discrete (Nominal)	ANOVA

4.2.3.1 *Correlations*

Correlations are used to describe the strength of relationships between two variables. The correlation coefficient ranges from -1 to 1 with correlations closer to zero signifying weak relationships and strong relationships occurring when values are closer to one or minus one. A positive (+) or negative (-) sign before a correlation indicates the direction of the relation where a positive sign means a positive relationship, indicating that an increase in one variable results in an increase in the other variable or a decrease in one variable results in a decrease in the other variable. However, a negative relationship means an increase in one variable result in a decrease in the other variable. Table 4.12 (Hinkle, Wiersma, & Jurs, 2003) provides a rule of thumb that enables one to interpret the results of the correlations.

Table 4.12: Rule of thumb for analysis of correlation results

Size of Correlation	**Interpretation**
.90 to 1.00 (-.90 to –1.00)	Very high positive (negative) correlation
.70 to .90 (-.70 to -.90)	High positive (negative) correlation
.50 to .70 (-.50 to -.70)	Moderate positive (negative) correlation
.30 to .50 (-.30 to -.50)	Low positive (negative) correlation
.00 to .30 (.00 to -.30)	Little if any correlation

Table 4.13: Correlations of the continuous variables

		Math Performance	**R^2**
Age	Pearson Correlation	-0.382	14.6
	Sig. (2-tailed)	0.000	
	N	11818	
Family SES	Pearson Correlation	0.504	25.4
	Sig. (2-tailed)	0.000	
	N	11889	
Adult Involvement	Pearson	-0.08	0.64
	Sig. (2-tailed)	0.000	
	N	11703	

School Climate	Pearson	0.049	0.24
	Sig. (2-tailed)	0.000	
	N	11790	

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

There is a significant negative relationship between Mathematics performance and age with a Pearson correlation r= -0.382, p-value (2-tailed) < 0.001. Age accounts for 14.6% of the variability in Mathematics performance. This variability was calculated using R^2 which is the coefficient of determination. The results show that a low positive association exists between age and Mathematics performance (see Table 4.13).

A statistically significant relationship is observed between family SES and performance with Pearson correlation r = 0.504, p-value (2-tailed) < 0.001 which is higher than that for learner age. This result shows that moderate positive association exists between family SES and Mathematics performance. SES accounts for 25.4% of the variability in Mathematics performance (see Table 4.13).

Adult involvement shows a significant relationship with Mathematics performance; r (Spearman correlation) = -0.08; p-value (two tailed) < 0.001. The correlation shows that there is very little association between adult involvement and Mathematics with adult involvement only explaining close to 1% of the variance in Mathematics performance (see Table 4.13).

There appears to be a very low significant relationship between school climate and Mathematics performance (r = 0.049; p-value (two tailed) < 0.001) School climate only accounts for 0.24% of the variation in Mathematics performance (see Table 4.13).

4.2.3.2 One-way Analysis of Variance (ANOVA)

An analysis of variance is a way to test the equality of means at one time by using variances. The assumptions of ANOVA are as follows:

- The population from which the sample was drawn is normally distributed;
- The samples are independent;
- The variances of the population are equal.

The general hypothesis that is tested in an ANOVA is:

H_o: There is no difference in the mean level of Mathematics performance among the different population groups (African versus Other).

H_a: There is a difference in the mean level of Mathematics performance among the different population groups (African versus Other).

Table 4.14: Anova: relationship between Mathematics and the discrete variables

		ANOVA output		
Variable	**Category**	**Mean**	**F**	**Sig.**
Race	Other	388.45	56797.56	0.000
	African	341.83		
Test language vs. home language LoLt	Test lang NOT same as home lang	339.18	167159.80	0.000
	Test lang SAME as home lang	428.71		
Family structure	2 parent	363.88	15134.66	0.000
	Other	343.35		
Home educational resources	Many resources	487.37	56880.90	0.000
	Some resources	362.33		
	Few resources	333.34		
Bullying	Almost never	392.55	54879.66	0.000
	About monthly	361.82		
	About weekly	322.05		
Like learning Maths	Like learning Maths	378.11	24042.16	0.000
	Somewhat like learning Maths	338.61		
	Do not like learning Maths	347.73		
Value Maths	Value Maths	363.98	17125.43	0.000
	Somewhat value Maths	340.71		
	Do not value Maths	308.64		
Confidence in doing Maths	Confident	427.48	44720.91	0.000
	Somewhat confident	349.15		
	Not confident	344.37		

Table 4.15: Bonferroni tests to evaluate between group differences

Variables	I	J	Mean Difference (I-J)	Std. Error
Home Educ. Resources	Many Resources	Some Resources	125.04*	0.72
		Few Resources	154.04*	0.72
	Some Resources	Few Resources	29.00*	0.15
Bullying	Almost never	About monthly	30.72*	0.21
		About weekly	70.50*	0.22
	About monthly	About weekly	39.77*	0.19
Like learning Maths	Like learning Maths	Somewhat like learning Maths	39.50*	0.18
		Do not like learning Maths	30.38*	0.25
	Somewhat like learning Maths	Do not like learning Maths	-9.12*	0.25
Value Maths	Value Mathematics	Somewhat value Maths	23.26*	0.21
		Do not value Maths	55.34*	0.34
	Somewhat value	Do not value Maths	32.08*	0.38
Confidence in doing Maths	Confident in learning Mathematics	Somewhat confident	78.33*	0.28
		Not confident	83.12*	0.29
	Somewhat confident	Not confident	4.79*	0.18

* mean difference is significant at the 0.001 level

Table 4.14 shows that population group has a significant effect on Mathematics performance; hence the H_o is rejected in favour of the H_a and it is concluded that there is a significant difference among the mean levels of Mathematics performance, ($F = 56797.6$; p-value <0.001). The mean Mathematics value for Africans is 341.83 and for the "Other" population groups combined is 388.45 (which is significantly higher).

A similar result is observed for language of instruction and learning. The H_o is rejected in favour of the H_a and it is concluded that there is a significant difference in the means; ($F= 167159.8$; p-value < 0.001). The mean Mathematics values for the test language being the same as the home language is 428.71, which is significantly higher than when the language of testing and the home language differ (339.18).

Table 4.14 shows that family structure has a significant effect on Mathematics performance and hence the H_o is rejected in favour of the $H_{a;}$ this indicates that there is a significant difference among the mean levels of Mathematics performance, ($F = 15134.66$; p-value <0.001). The mean Mathematics value for 2-parent households is significantly higher at 368.88 compared to the other group at 343.35.

When looking at the mean Mathematics scores between categories of the educational resources in the home an improvement in mean Mathematics scores is observed between those learners who said they had many resources (having more than 100 books in the home, Internet, own room and either parent with a degree or higher qualification) and those who said they had few (fewer than 25 books, no Internet, no own room, neither parent has a secondary school qualification). There is a 154 point difference between learners who have many resources and those who said they had few. The ANOVA results in Table 4.14 show that a significant difference is observed; $F = 56880.9$; p-value <0.001. The Bonferroni test shows that significant differences occur between all the pairwise comparisons of this variable (see Table 4.15).

It is clear from Table 4.14 that bullying has an effect on learner Mathematics performance. The H_o is rejected in favour of the H_a and the conclusion thus is that there are differences between the mean Mathematics levels ($F =54879.66$; p-value <0.001). The Bonferroni strengthens this result and in Table 4.15 it is shown that there are significant differences between all levels of the bullying variable. Learners who are almost never bullied had an average score of 393 which is significantly higher than learners who are bullied on a weekly basis (322) as well as those bullied once or twice a month (362).

The composite constructs that measure a learner's perception of Mathematics (liking and valuing Mathematics as well as confidence in doing Mathematics) are all significant (see Table 4.14) and hence the H_o is rejected in favour of the H_a; it is concluded that there are significant differences in the Mathematics scores between the categories of these variables (see Table 4.15). Learners who like learning Mathematics have an average Mathematics score of 378 (F = 24042, p-value< 0.001) which is higher than learners who say they somewhat like learning Mathematics and have an average score of 339. Strange, however, is the fact that learners who say they do not like learning Mathematics had an average Mathematics score that is higher than those learners who said they somewhat like learning Mathematics.

Similarly learners who value Mathematics had an average Mathematics score of 364 which is higher than those who said they somewhat valued Mathematics.

4.2.4 School/teacher level descriptive statistics

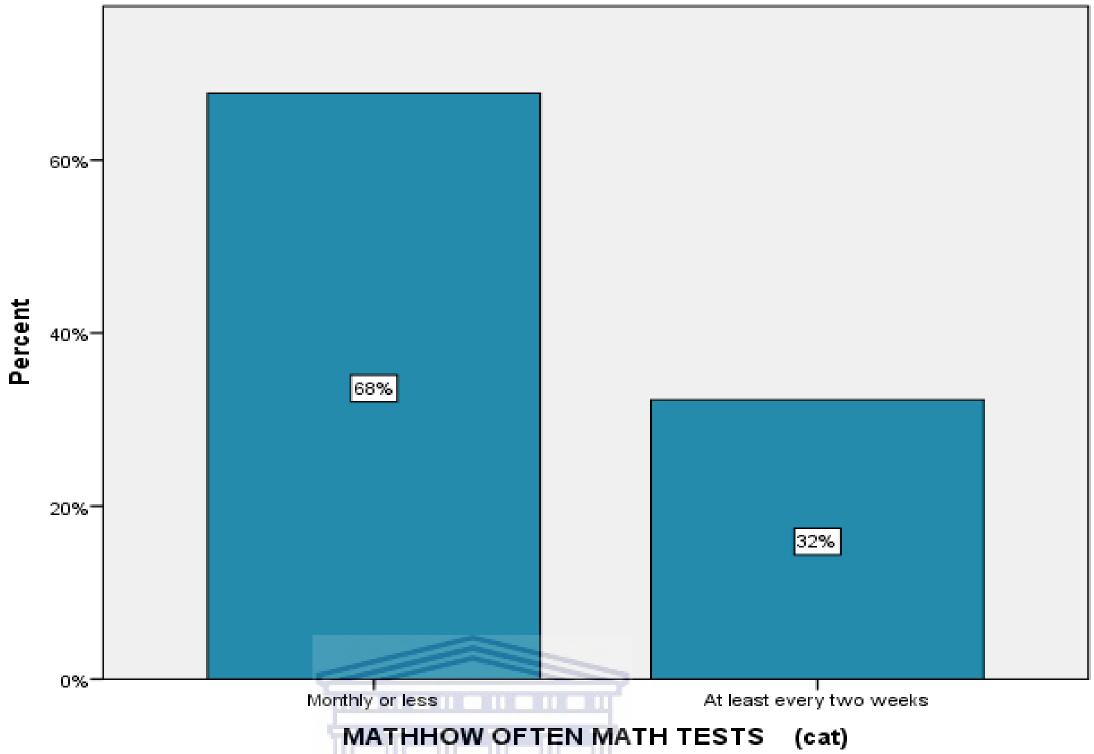
Data obtained from the school and teacher data constitute the second level of the multilevel analysis and hence in this section only variable spread is discussed and not in relation to performance because individual learner performance cannot directly be linked to school information. The analysis is done using a series of tables and graphs where necessary.

The sample consisted of 298 schools and of these 285 of the sample were realised which provided a sample realisation of 95.6%, which is exceptionally high.

A number of variables (discussed in Chapter 3, Section 3.6.4.2) were chosen from the principal and teacher questionnaires in an attempt to explain school quality and because the survey was administered to in-tact classes; where only one class was selected per school, it meant that the principal and the teacher data could be analysed at the same level. Data is discussed and displayed using weighted percentages and unweighted counts.

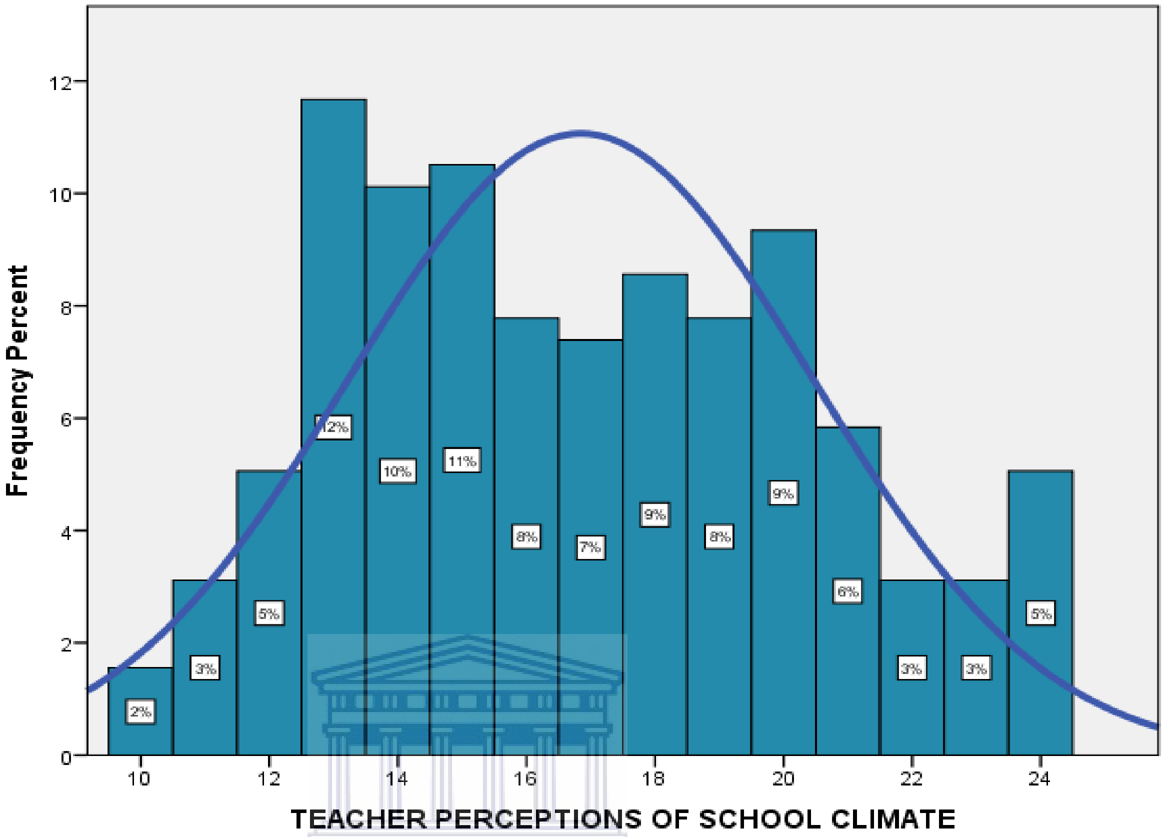
Teachers were asked how often tests were administered to learners. In 68% of the cases teachers said that tests were administered at least once a month (Figure 4.15); however, in 32% of the cases tests were administered every two weeks.

Figure 4.15: How often Mathematics assessments are done



The Maths teachers' perception of school climate is a measure that was derived and that asked teachers how they would characterise issues of job satisfaction, teachers' understanding of the curriculum, expectations of student achievement and parental support (details of this composite measure is provided in Chapter 3, Section 3.6.4.2). Teachers could score a minimum of 8 (unacceptable school climate) to a maximum of 24 (very good school climate). Figure 4.16 shows that 33% of the teachers rated the school climate to be between 13 and 15 and another 33% provided a score of between 16 and 20.

Figure 4.16: Distribution of teachers' perception of school climate



Class Size was originally a continuous variable which was normally distributed as can be seen in Figure 4.17. This variable was categorised into four groups, where 28% of the school had between 31 and 40 learners per class on average. In 25% of the cases schools had on average less than 30 learners per class and an over whelming 45% of schools had on average more than 41 learners per class (see Figure 4.18). For HLM modelling purposes, this newly created categorical variable was dichotomised to create 4 separate variables; one for each of the groups.

Figure 4.17: Distribution of class size variable

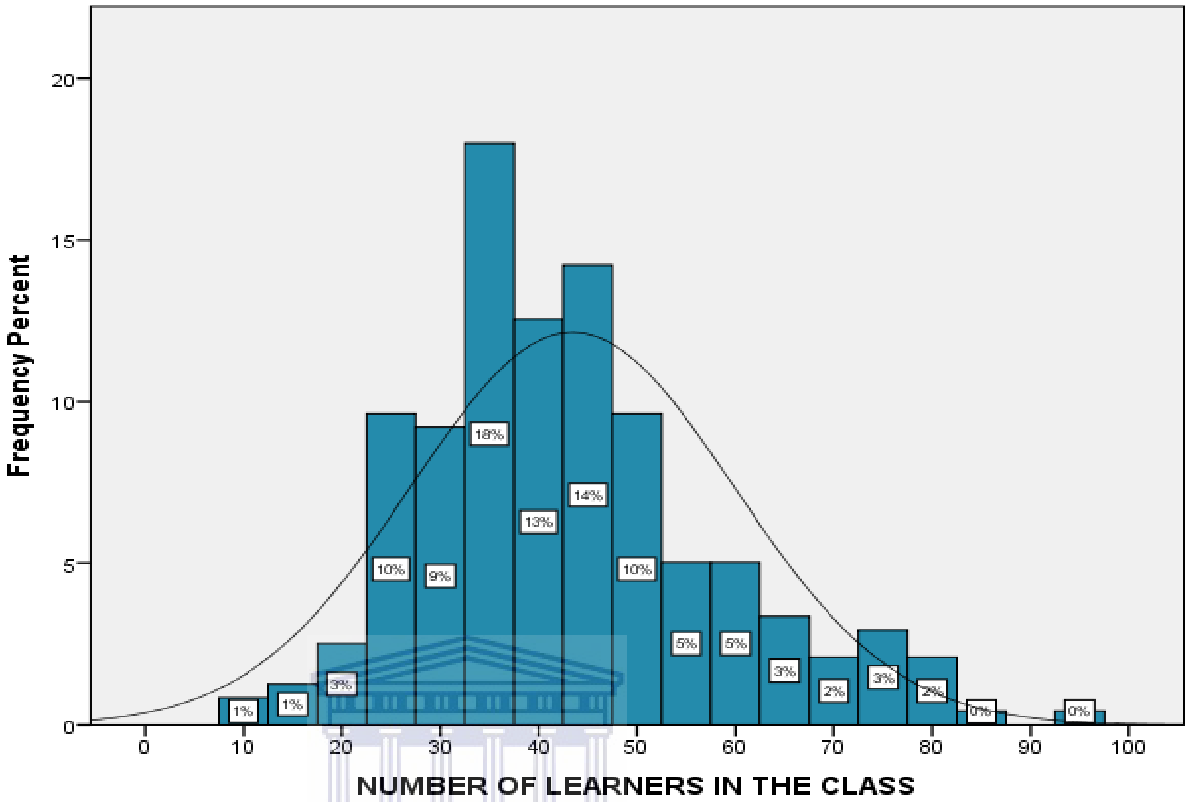
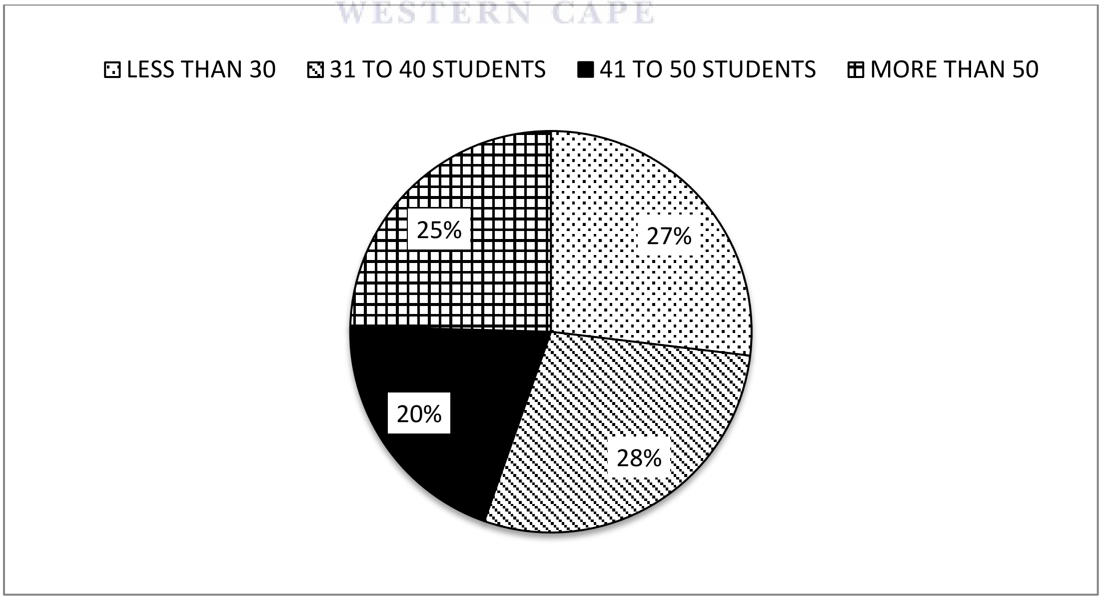
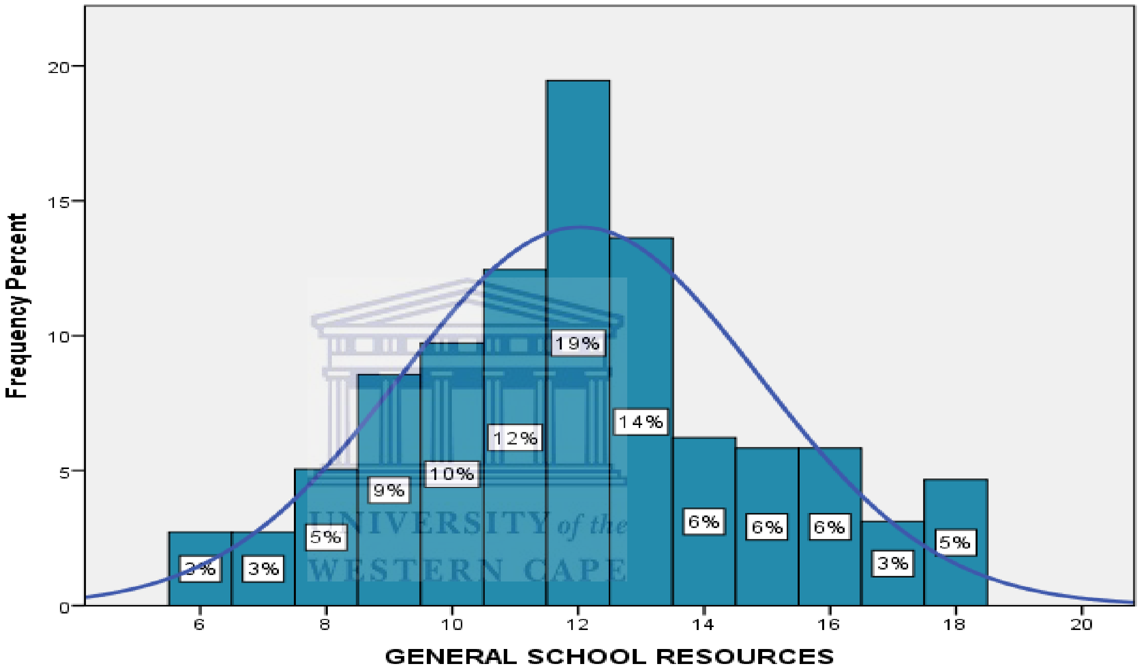


Figure 4.18: Class size



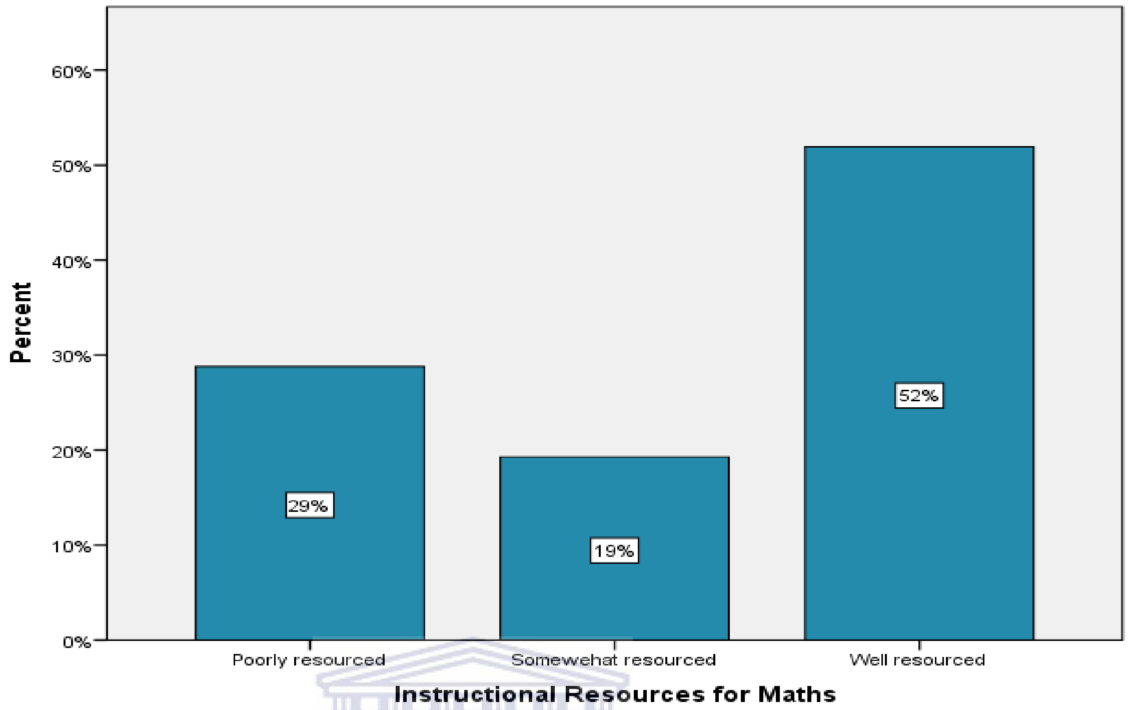
School resources are a calculated measure that consists of a number of questions referring to general resources available at the school. Questions included in the measure relate to instructional material (textbooks), stationery, school infrastructure, etc. This measure ranged from 6 (poorly resourced) to a maximum of 18 (well resourced). Most teachers indicated a score of 12 (19%), indicating that schools were neither poorly resourced nor well-resourced (see Figure 4.19). In only 5% of the cases teachers reported the schools to be well resourced; still of concern is the 3% (see Figure 4.19) who reported that their schools were poorly resourced.

Figure 4.19: Distribution of general school resources



Resources used for Mathematics instruction are also a measure or construct created that asked questions such as whether teachers had specialisation in Mathematics or if they had computers to use for Mathematics instruction. This measure also ranges from 6 (poorly resourced) to 18 (well resourced). This measure was then categorised into poorly resourced, somewhat resourced and well resourced (details of the measure provided in Chapter 3, Section 3.6.4.2). More than 52% (see Figure 4.20) of teachers said that schools were well resourced; almost 29% said that the schools were poorly resourced and a further 19% said their schools were only somewhat resourced.

Figure 4.20: Distribution of resources for Mathematics instruction



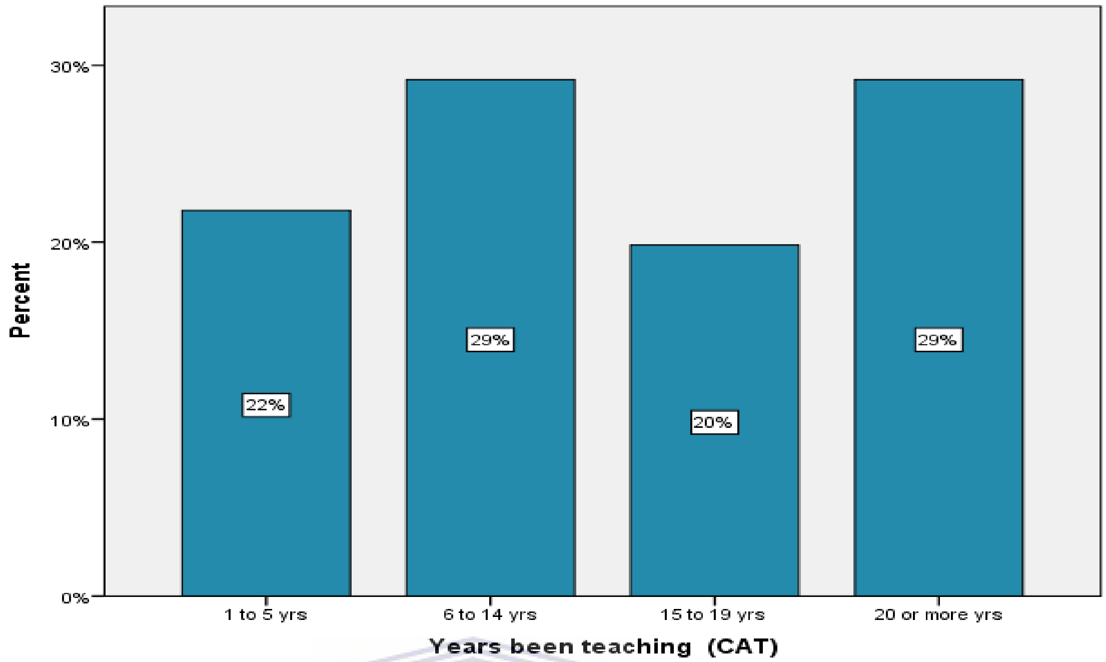
Teachers were asked if Mathematics was their major area of study and an overwhelming 90% said they had majored in Mathematics (see Table 4.16).

Table 4.16: Mathematics as major area of study

	n	%
No Maths Major	35	10.0%
Maths Major	222	90.0%
Total	257	100.0%

Almost 80% of teachers had more than 6 years' experience and 29% had 20 or more years' experience (see Figure 4.21). It would seem that the TIMSS selected teachers are very experienced when one looks at the number of years they have taught.

Figure 4.21: Number of years teaching experience



Looking at the highest qualification it is interesting to note that 52% (see Table 4.17) completed a university degree or higher, which is only slightly more than the 47% of teachers whose highest qualification is a diploma.

Table 4.17: Professional qualification

	n	N %
Matriculation or Post-Matriculation Certificate	5	1.0%
Completed diploma	95	46.7%
Completed first degree	101	36.3%
Completed honours degree or higher	43	15.9%
Total	244	100.0%

A measure was created to quantify whether instruction was affected by shortages in Mathematics resources. The measure is composed of twelve statements that principals had to respond to and ranged from "Not at all affected" to "Affected a lot". The 12 statements were then divided into broader categories to aid in analysis (see Table 4.18). Table 4.18 shows that Information and Communication Technology (ICT) is most affected by a lack of computer software for Mathematics instruction (33%) as well audio-visual resources for Mathematics instruction (32%). In terms of general infrastructure it seems that most schools are affected by a lack of supplies like paper and stationery (29%) with close to 60% being somewhat affected by a lack of school buildings and heating and cooling systems (63%). More than 50% of schools are somewhat affected by a lack of resources for Mathematics insruction. Table 4.18 shows that 68% of schools are somewhat affected by a lack of teachers who have specialised in Mathematics compared to only 15% who said they were affected a lot by teachers who had specialised in Mathematics while studying.

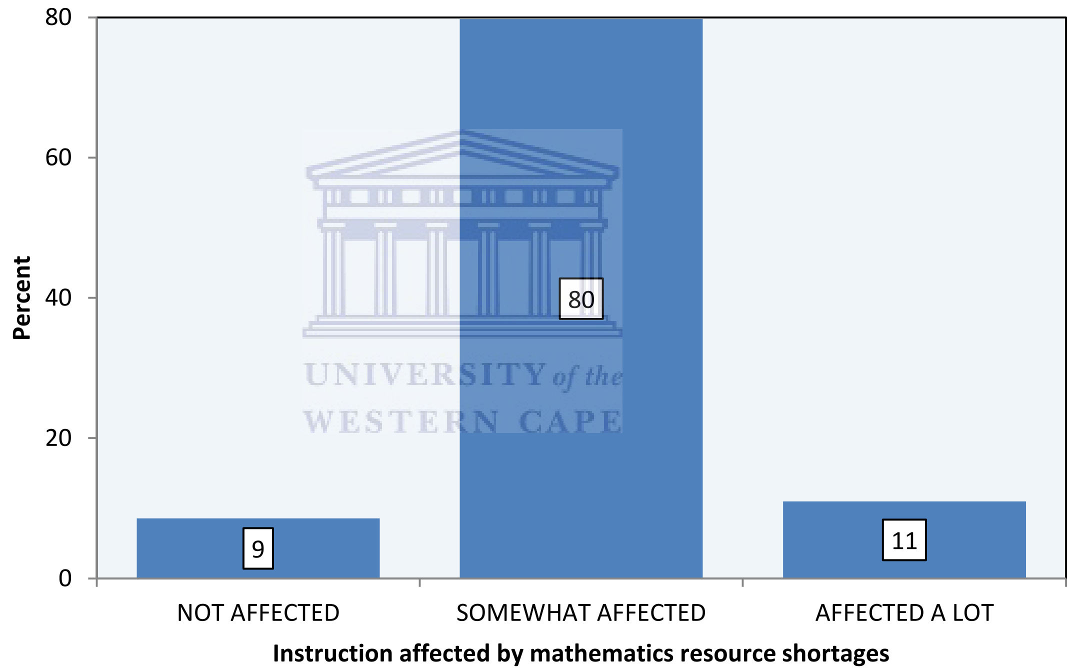
Table 4.18: Statements included in the Shortage of Instructional Resources measure

Categories	**Statements**	**Not at all affected**	**A little/ somewhat affected**	**Affected a lot**	**Total**
ICT	**Computers for Maths instruction**	23	59	18	100
	Computer software for Maths instruction	40	27	33	100
	Audio-visual resources for Maths instruction	37	31	32	100
	Technologies	31	41	28	100
General Infrastructure	**Supplies, for example stationery, textbooks**	34	37	29	100
	School buildings	22	59	19	100
	Heating/cooling and lighting systems	16	63	21	100
Resources for Mathematics Instruction	**Library materials relevant to Maths instruction**	30	48	22	100
	Calculators for Maths instruction	27	51	22	100
	Instructional material	27	52	21	100
	Instructional space	24	56	20	100
Teachers	**Teachers with specialisation in Maths**	17	68	15	100

The measure was categorised where a score greater than 11 indicated that schools are not affected by resource shortages; a score less than 7.3 indicates schools that were affected a lot and the third category ranges between scores greater than 7.3 but less than 11 and collectively are referred to as those schools somewhat affected.

An overwhelming majority of principals (80%) said their schools were somewhat affected by a shortage of instructional resources and about 11% (Figure 4.22) said they were affected a lot.

Figure 4.22: Instruction affected by lack of resources for Mathematics instruction



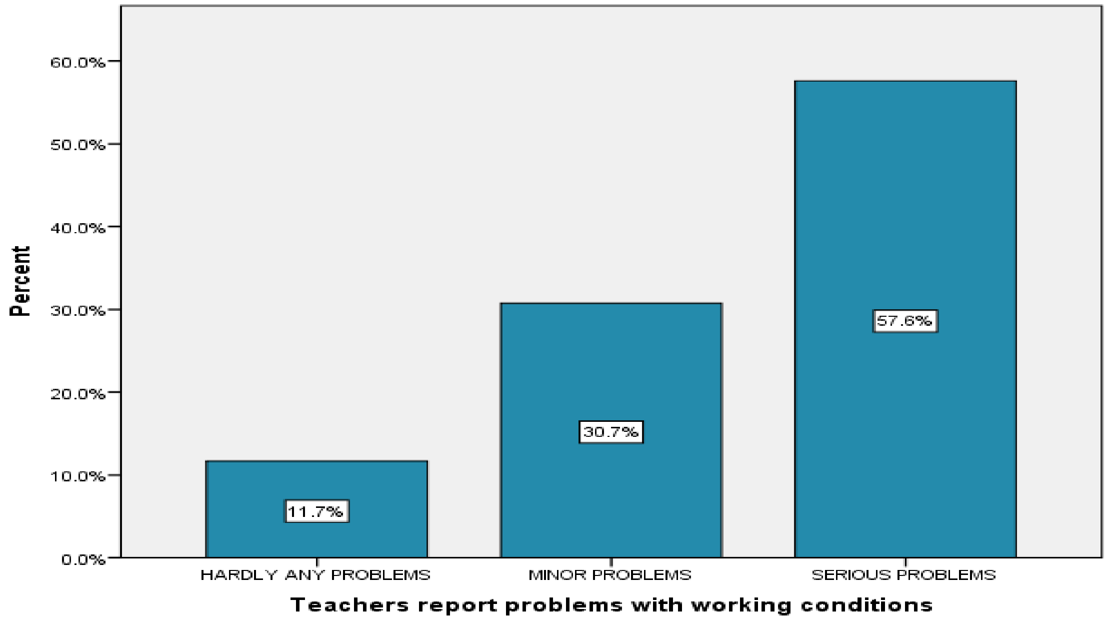
Teachers reporting problems related to their working conditions is another measure created and includes responses to five questions relating to potential problem areas. Teachers reported that overcrowded classrooms were a serious problem (40%) and interesting to note is that 32% stated that there was no problem with the teaching hours (see Table 4.19).

Table 4.19: Statements included in the working conditions measure

	Not a problem	Minor problem	Moderate problems	Serious problems	Total
The school building needs significant repair	25	29	24	23	100
Classrooms are over-crowded	20	18	22	40	100
Teachers have too many teaching hours	32	26	29	13	100
Teachers do not have adequate work space	28	25	25	22	100
Teachers do not have adequate instructional material	22	26	28	24	100

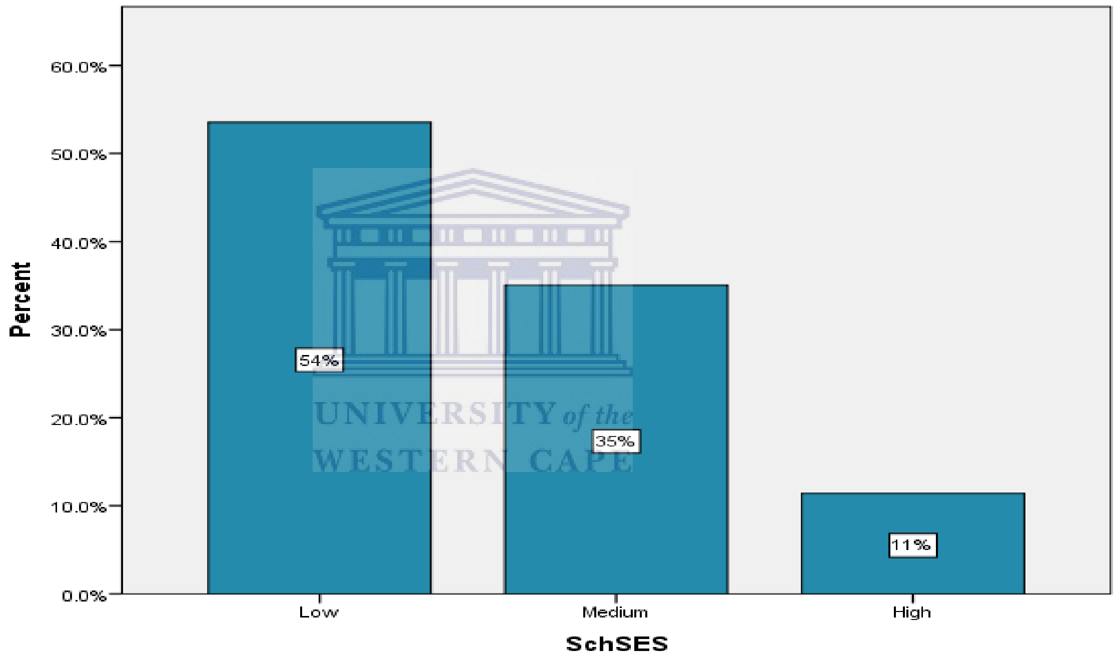
The teacher working conditions measure created was categorised into those schools with "hardly any problems" with a score of more than 11.7; "moderate to serious problems" with a score of no more than 8.9 and finally "minor problem" are those with a score less than 11.7 but greater than 8.9. Figure 4.22 shows that an overwhelming 57.6% of teachers reported having serious problems compared to 30.7% who reported minor problems and only 11.7 % said they had hardly any problems.

Figure 4.23: Teachers report problems with working conditions at the school



School socio-economic status is a composite measure which is comprised of three questions responded to by the principal. They were asked whether the majority of the learners came from economically affluent or disadvantaged homes, the number of people living in the area surrounding the school as well as the average household income level of the immediate area surrounding the school. Figure 4.23 shows that the principals indicated that just more than half (54%) of the people living in the area close to their school are of a low SES compared to the 11% who said the schools are in affluent areas.

Figure 4.24: School socio-economic status



4.3 Results from the HLM models

This section of the thesis provides the results of the HLM analysis and is discussed as follows:

- Evaluation of the HLM assumptions
- HLM analysis:
    - The null/unconditional model
    - Analysis and results of each research question

A series of 25 models was created in an attempt to answer the research questions. As with all HLM analyses it is important to begin with the unconditional model which is a model of the dependent variable with no level-1 or level-2 variables added. From the analysis of the unconditional model an important statistic to calculate is the total amount of variability in the dependent variable *Mathematics performance*.

A very important aspect to consider when doing HLM analysis is that only complete data is allowed at level-2 or higher; hence all incomplete or missing data had to be either removed or imputed. In this analysis, because the rate of missing information is not high, a decision was made to exclude all missing information from the data which resulted in a sample used for analysis being 9 645 learners and 254 schools as opposed to the original realised sample of 11 915 learners and 285 schools, showing that 81% of the realised sample was used for the HLM analysis.

4.3.1 Evaluation of HLM assumptions

As stated in Chapter 3 there are general assumptions as is the case of simple linear regression that need to be met to ensure the HLM models created are tenable. These are the following:

- All r_{ij} are independent and normally distributed with mean 0 and variance σ^2, for every level-1 unit within each level-2 unit.
- All level-2 random elements are multivariate normal, each with mean zero and variance/covariance matrix "T".
- Error terms across levels are independent.

The level-1 residuals are approximately normally distributed (see Figure 4.25) and the scatter plot between the level one residuals and Mathematics performance's (see Figure 4.26) homogeneity of level-1 variance is evident.

Figure 4.25: Histogram of Level-1 residuals

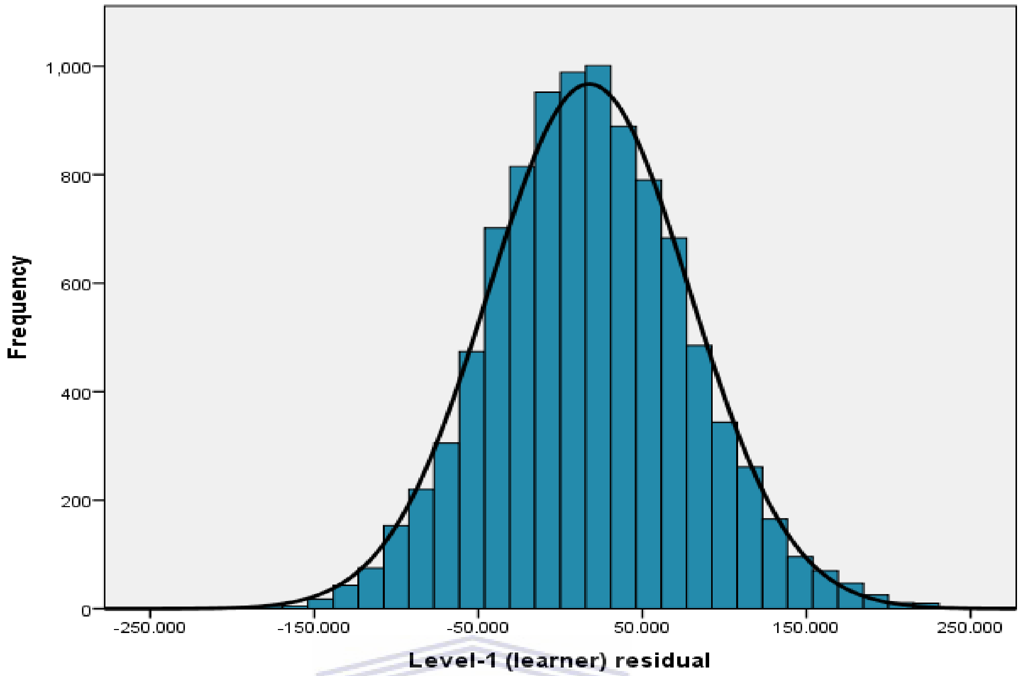
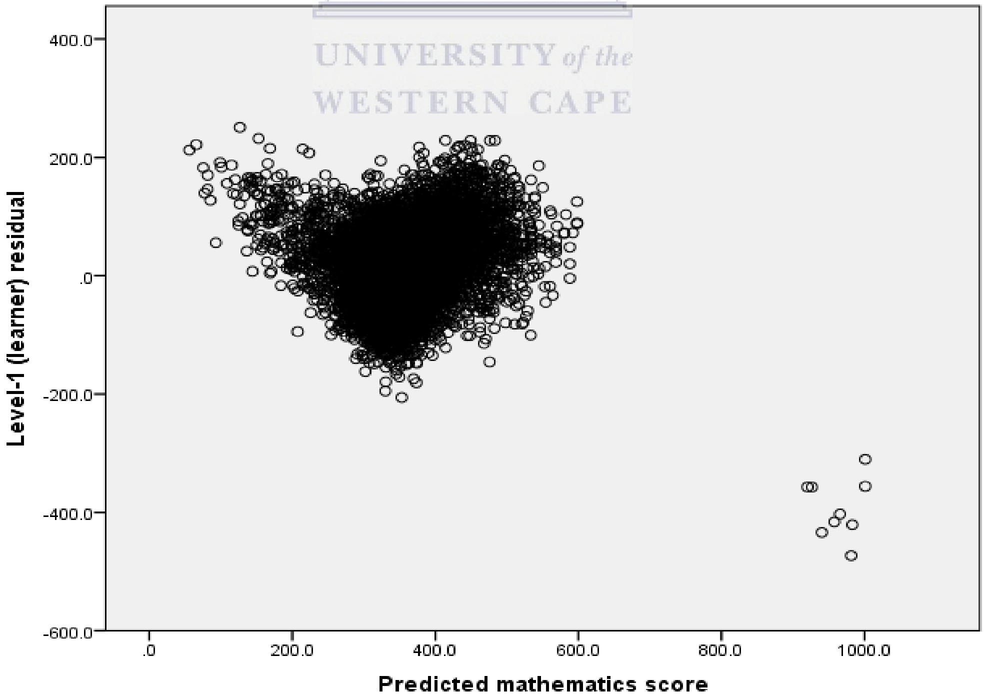


Figure 4.26: Scatter plot of predicted Mathematics score and level-1 residual



The empirical Bayes residuals for the slopes and intercepts were used to construct the graphs for the level-2 random effects. In Figure 4.27 the level-2 intercept residuals appear to be approximately normally distributed with homogeneous variance which is clear from the spread of the scatter plot in Figure 4.28.

Figure 4.27: Level-2 intercepts residuals

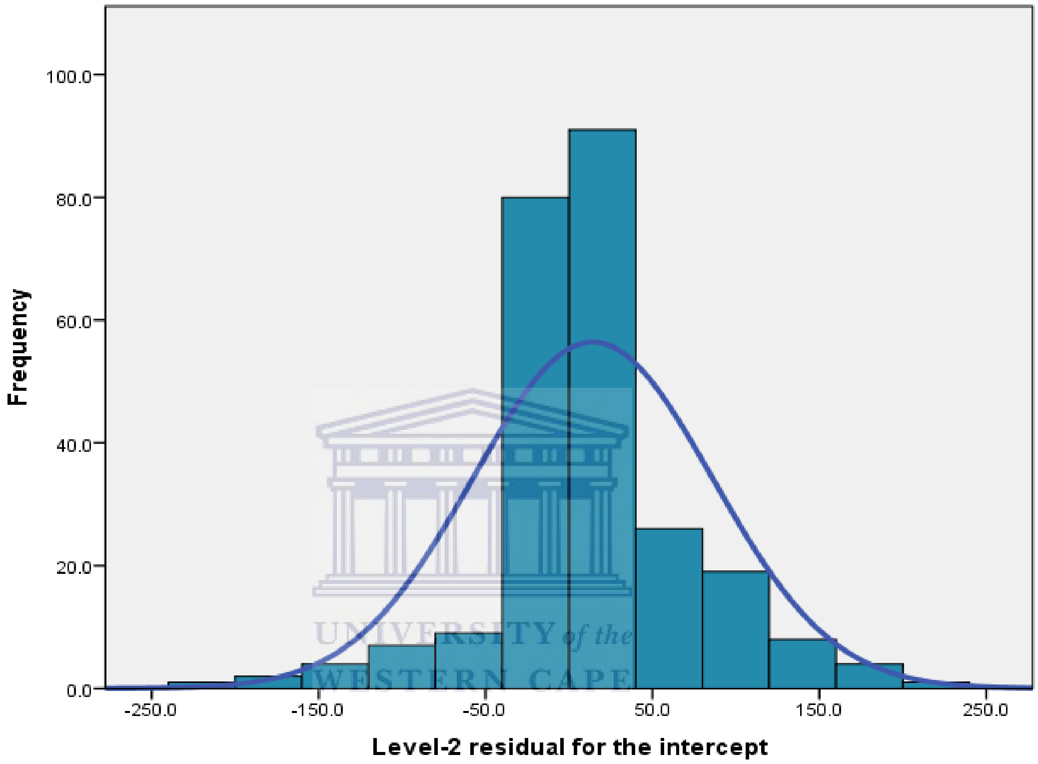


Figure 4.28: Scatter plot to show homogeneity of variance

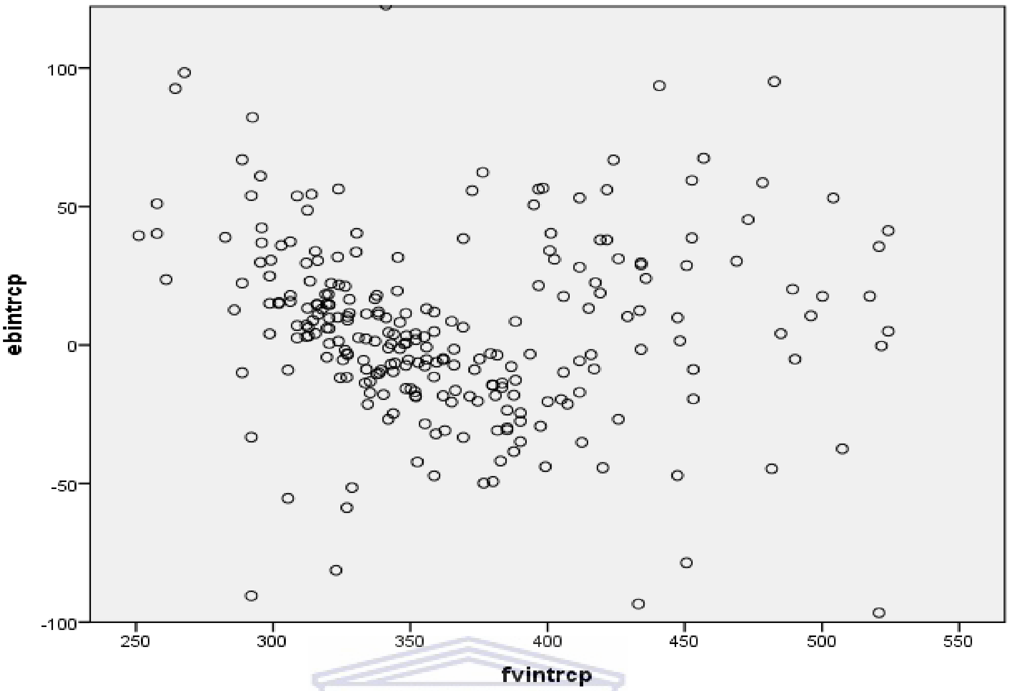


Figure 4.29 provides the histograms of residuals for each of the level-1 variables which provide a graphic display of the approximate distribution of the level-1 variables. The histograms of all the level-1 slopes appear to be normally distributed. Figure 4.30 on the other hand provides information on the homogeneity of the level-1 variables. On inspection of these scatterplots (see Figure 4.30), the variances are homogeneous.

Figure 4.29: Histograms of level-1 variables

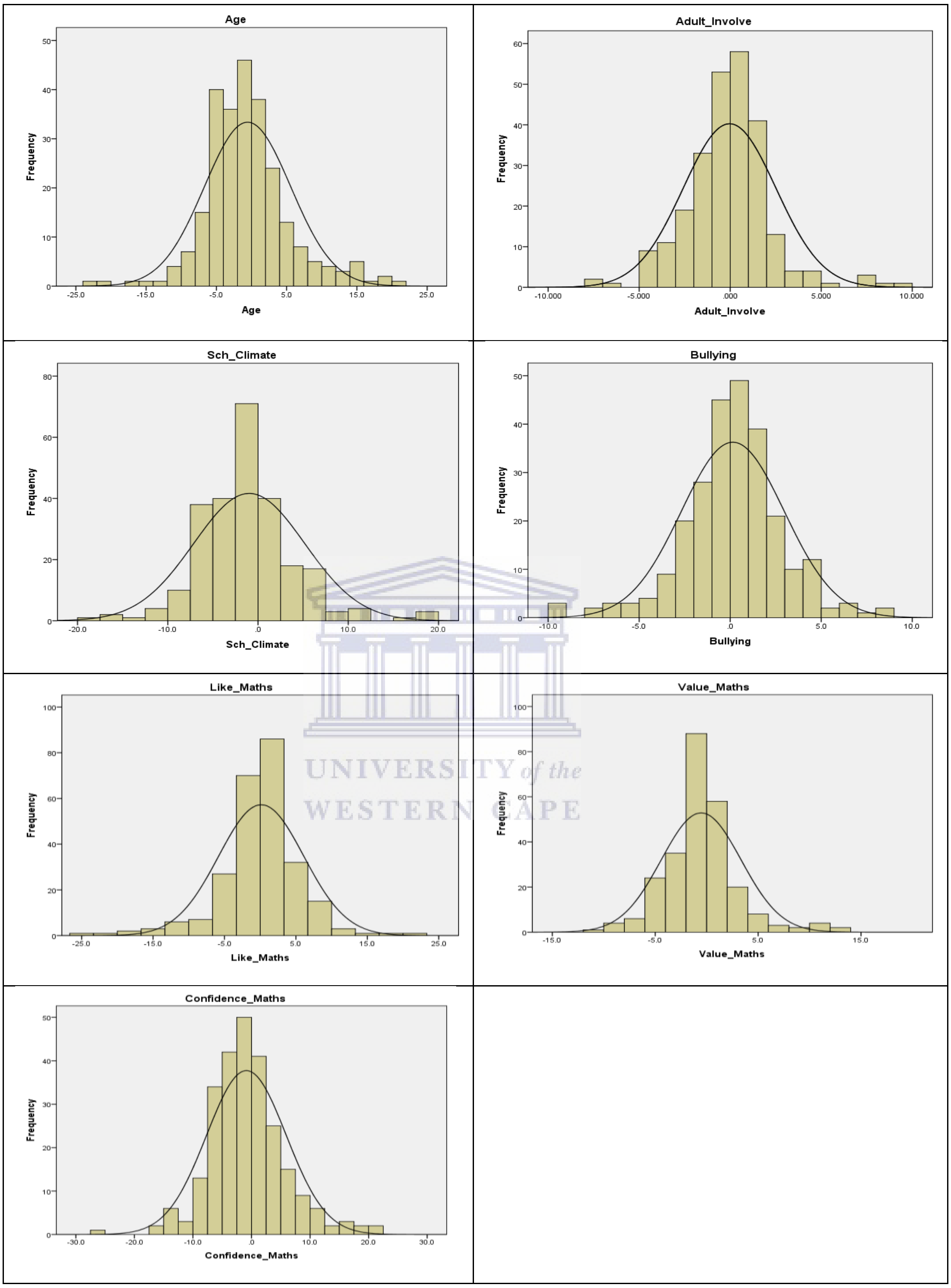
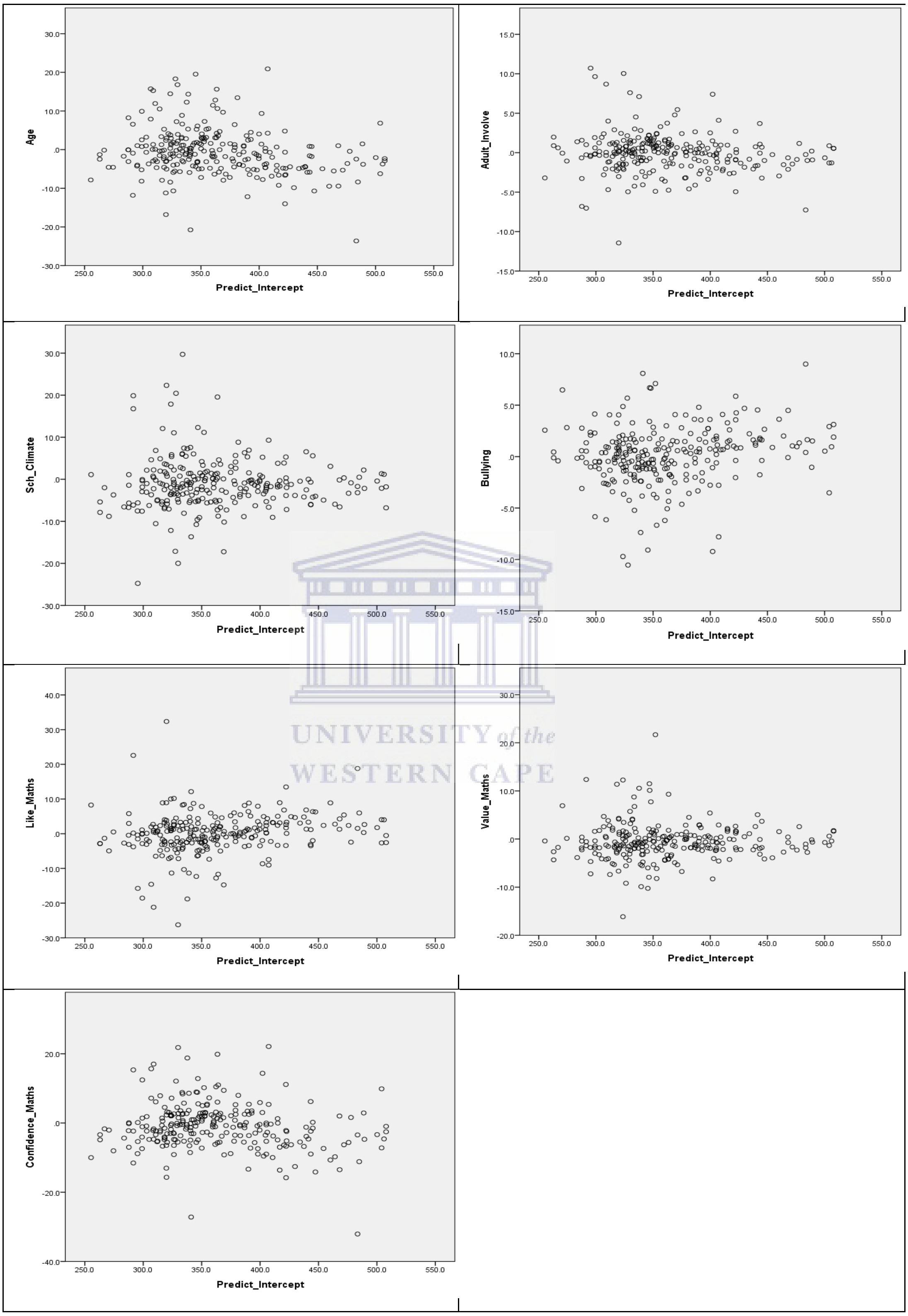


Figure 4.30: Scatter plots of level-1 variables



4.3.2 HLM analysis

4.3.2.1 The unconditional model (Model 1)

The first stage in any HLM analysis is that of the unconditional model, also referred to as the Null Model which by its very name implies that no level-1 or level-2 predictors are added to the model. The unconditional model allows one to estimate the mean mathematics score across all schools as well as the variance explained between schools. The aim of the HLM model thus is to add level-1 and level-2 variables so that it reduces the variance between schools as well as between learners.

The overall average Mathematics score, which is also referred to as the fixed effect, is 344 (SE=9.17, $p < 0.001$). The average Mathematics score is significantly different across schools ($\tau = 5242.61$; $p < 0.001$) (see Table 4.20).

Table 4.20: HLM Unconditional or Null Model

Model	Parameter	Estimates
1	Intercept	344**
	τ_{00} (between school variance)	5242.61
	σ^2 (within school variance)	3196.27
	Variance explained	0.62 (62%)
	Standard Error	9.17

** Significant (< 0.001)

In the unconditional model variation is partitioned into two components, namely between schools (Var (μ_{ij}) = τ_{00}) and within schools (Var (r_{ij}) = σ^2). In Table 4.20 the between school variance is 5242.61 and the within school variance is 3196.27; the proportion of the total variance explained by differences in schools is determined as follows:

$$\rho = \frac{\tau_{00}}{\tau_{00} + \sigma^2}$$

$$= \frac{5242.61}{5242.61 + 3196.27}$$

$$= 0.62 = 62\%$$

Hence it can be concluded that 62% of the variation occurs between schools.

4.3.2.2 Research question 1

To what extent are learner background variables associated with Mathematics performance? The following variables have been considered for this research:

- Learner age;
- Adult involvement in learning at home;
- Race;
- Language of instruction and learning compared to home language (LoLt);
- Family structure;
- Family socio-economic status;
- Learner perception of school climate;
- Educational resources in the home;
- Bullying in the school (Learner perception);
- Learners like learning Mathematics;
- Learners valuing Mathematics;
- Learners self-confidence in learning Mathematics.

To answer this question a series of models was developed where each of the level-1 variables was included individually to the unconditional model resulting in a total of 13 models, including the unconditional model. Depending on the statistical significance of these variables a final level-1 model (model 14) was developed that included only the significant level-1 variables.

Table 4.21 provides the details of the HLM analysis for models 1 to 13 and the section that follows provides a detailed analysis of the variables that were significant only. All insignificant variables have been high-lighted in the table. Variables found to be insignificant are the following:

- Language of instruction and learning is the same as the test paper language (LoLt) with a p-value = 0.725.
- Nuclear family with a p-value = 0.225.
- Family SES with a p-value = 0.613.

- Adult involvement with a p-value = 0.682.
- Home educational resources with a p-value = 0.210.

Working from model 2 in Table 4.21 the average school mean for Mathematics performance is 344 which are similar to that obtained from the unconditional model. From the descriptive analysis (see

Table 4.13) age has a significant negative effect on learner Mathematics performance; in fact, the results show that learners who are grade-age appropriate obtain higher scores than learners who are older. It was decided to group the age variable into three: one referring to learners of ages 10 to 13; one for learners who are grade-age appropriate (age 14 to 16) as well as a variable for learners who are older than they should be. The dichotomy of age group 14 to 16 was used as the reference category and Table 4.21 shows that age group 10 to 13 showed no significant difference when compared to learners ages 14 to 16. There is, however, a significant difference between the mean scores of learners who are older than the appropriate age and those who are aged 14 to 16 (grade appropriate age). Learners who are appropriately aged score 26 points higher than those learners aged 17 and older (p-value <0.001; SE= 3.09).

Model 3 in Table 4.21 shows a significant difference in the average Mathematics score between Black/African and the other racial groups (p-value = 0.014, SE = 4.55). The results show that learners who are Black/African score on average 11.93 points lower than the other racial groups combined.

Model 8 (learner perception of school climate) in Table 4.21 shows results similar to those of race in the sense that there is a significant difference between Mathematics scores of learners' who perceive the school climate to be good compared to those from schools where the climate is poor (p-value = 0.002, SE = 2.44). Learners from schools with a good school climate score on average 9.75 points higher than learners who perceive their school climate to be poor.

Learners who report being bullied (model 10 in Table 4.21) at school scored 13 points lower than those learners who reported that they were not bullied. This difference in average Mathematics score is significant (p-value = 0.000; SE = 1.84).

Learners' attitude towards Mathematics as indicated by their liking Mathematics (model 11), valuing Mathematics (model 12) and being confident in learning Mathematics (model 13) in Table 4.21 shows highly significant differences in average Mathematics performance at p-value <0.001. Learners who say they like Mathematics score on average 27 points higher than learners who say they do not like Mathematics. Similarly learners who say they value Mathematics score on average 18 points higher than those who do not value Mathematics, and finally learners who are confident in learning Mathematics score 28 points higher than those who are not confident in learning Mathematics.

Of the significant learner level factors mentioned the variable with the most significant impact (in order of highest average change) is learner confidence in Mathematics (28 point difference); such learners obtain a higher score than learners who are not confident in learning Mathematics. Learners who like Mathematics on average score 27 points more than learners who do not like the subject. Age is another important factor where learners who are over age score 26 points lower than learners of appropriate grade age. Learners who value Mathematics score 18 points higher than learners who do not value Mathematics and similarly learners who are bullied score 13 points lower than learners who are not bullied. Race has a significant effect on learner performance in that African learners scores 10 points lower than learners of other race groups. Learners who rate their school climate positively score on average 10 points more than learners who give their school a poor rating Table 4.21.

Table 4.21: HLM Level-1 analysis (Model 2 to 13)

Model	Variable	Fixed Effect		
		Estimates	SE	p-value
2	Intercept (reference category was ages (14 – 16)	343.86	9.18	0.000
	Age (10 – 13)	-12.67	15.54	**0.421**
	Age (17 plus)	-26.01	3.09	0.000
3	Intercept (reference category race other)	343.85	9.16	0.000
	Race - Black	-11.93	4.55	0.014
4	Intercept (home lang and test lang different was reference category)	343.85	9.17	0.000
	LoLt	1.616	4.57	**0.725**
5	Intercept (other family struc. was reference category)	343.85	9.17	0.000
	Nuclear family	4.16	3.34	**0.225**
6	Intercept (High Family SES was reference category)	343.86	9.17	0.000
	Family SES	-0.90	1.78	**0.613**
7	Intercept (Very involved was reference category)	343.86	9.17	0.000
	Adult involvement	-1.14	2.70	**0.682**
8	Intercept (Very good climate was reference category)	343.85	9.17	0.000
	School climate	9.75	2.44	0.002
9	Intercept (Many resources was reference category)	343.85	9.17	0.000
	Home educational resources	3.63	2.84	**0.210**
10	Intercept (learners who were bullied weekly was reference category)	343.86	9.17	0.000
	Bullying	13.02	1.84	0.000
11	Intercept (Learners who did not like maths was reference category)	343.86	9.18	0.000
	Learner like Mathematics	26.787	2.178	0.000
12	Intercept (Learners who did not value maths was reference category)	343.86	9.17	0.000
	Learner value Mathematics	18.367	3.01	0.000
13	Intercept (Learners who did not have confidence in maths was reference category)	343.87	9.19	0.000
	Learner confidence	28.34	1.90	0.000

The following equation was used to calculate the variance explained after inclusion of each of the level-1 models created:

$$\textit{Within school variance} = \sigma^2 \text{ (null model) - } \sigma^2 \text{ (level-1 model) / } \sigma^2 \text{ (null model)}$$

$$\textit{between school variance} = \frac{\tau \text{ (null model)- } \tau \text{ (level-1 model)}}{\tau \text{ (null model)}}$$

Very little variance is explained between schools by the level-1 factors with a variance reduction of between 0 and 0.4% (see Table 4.22). The within school variance, on the other hand, explains more of the variance than the between school variance. By adding the level-1 variables the within school variance reduces from 0% (models 6 and 7) to 9.63% in model 12. The total variance explained (see Table 4.22) is the sum of the between school and within school variance and in total the variance reduction in the entire model ranges between 0% and 10%.

Table 4.22: Variance explained between unconditional model and models 2 to 13

Level-1 variable	**Model**	**τ00 (between school variance)**	**σ2 (within school variance)**	**Variance explained between schools (%)**	**Variance explained within schools (%)**	**Total Variance explained**
	Unconditional model (UM)	**5242.61**	**3196.27**			
Age	2 vs (UM)	5251.62	3076.77	0.17	3.74	3.91
Black	3 vs (UM)	5241.53	3180.71	0.02	0.49	0.51
LoLt	4 vs (UM)	5242.28	3191.97	0.01	0.13	0.14
Nuclear	5 vs (UM)	5242.29	3196.25	0.01	0	0.01
Fam SES	6 vs (UM)	5242.62	3196.04	0	0.01	0.01
Adult Involvement	7 vs (UM)	5242.73	3194.36	0	0.06	0.06
School Climate	8 vs (UM)	5245.59	3137.50	0.06	1.84	1.9
Home Educ Resources	9vs (UM)	5242.66	3193.08	0	0.1	0.1
Bullying	10 vs (UM)	5247.88	3111.16	0.1	2.66	2.76
Like Maths	11 vs (UM)	5262.85	2888.51	0.38	9.63	10.01
Value Maths	12 vs (UM)	5250.67	3076.48	0.15	3.75	3.9
Conf Maths	13vs (UM)	5263.84	2910.98	0.4	8.93	9.33

In the final level-1 model (model 14) all the level one variables were added to predict Mathematics performance but only those significant in model 14 were retained. Of interest is that some variables that were significant in the individual models became insignificant in the combined level-1 model (model 14). One such variable is adult involvement in the learning activities of the learner (see Table 4.23).

Table 4.23: Final level-1 model

Model	**Type**	**Parameters**	**Estimates**	**SE**	**P-value**
14	Fixed	Intercept	343.88	9.20	0.000
		Age 17 and older	-20.93	2.80	0.000
		Adult Involvement	-8.48	2.43	0.009
		Bullying	7.73	1.70	0.000
		Like Mathematics	16.57	2.03	0.000
		Value Mathematics	6.70	2.86	0.033
		Confidence in learning Mathematics	18.80	2.14	0.000
		Parameter	**Standard Deviation**	**Variance Component**	**P-value**
	Random	INTRCPT1, τ	72.68	5283.08	0.000
		level-1, σ^2	51.19	2620.36	
	Variance explained	**Variance explained between schools (%)**	**Variance explained within schools (%)**	**Total variance explained (%)**	
	Model 14 vs Unconditional	0.766	18.02	18.784	

Six of the 13 level-1 variables were significant in the final level-1 model (model 14) (see Table 4.23):

- Age (SE = 2.8, $p < 0.001$) which was also significant when entered as a single variable.
- Adult Involvement (SE = 2.43, $p = 0.009$) which was insignificant when added as a single variable.
- Bullying (SE= 1.70, $p < 0.001$).
- Learner likes Maths (SE = 2.03, $p < 0.001$).
- Learner values Maths (SE = 2.86, $p = 0.033$).
- Learner self-confidence in Maths (SE = 2.14, $p < 0.001$).

Interesting to note is that when all covariates are entered in the unconditional model, race and school climate become insignificant.

The coefficients in Table 4.23 provide information on the impact of the covariates on Mathematics performance. Age had the greatest impact on performance with learners aged 17 and older scoring almost 21 points lower than learners who are at the appropriate age for the grade. This is followed by learners who are confident (19 points higher) and then learners who like Mathematics obtaining 17 points more than learners who do not like the subject.

The final level-1 model (model 14) reduces the within school variance by almost 19% (see Table 4.23) which is almost 10% more than model 13 (learner confidence) which previously was the variable that explained the largest amount of variance. It seems that improving success in Mathematics learning within schools in South Africa will require strategies that help develop learners' confidence and positive attitudes in learning Mathematics.

4.3.2.3 Research question 2

To what extent are school resources associated with Mathematics performance? Level-2 variables used to measure school resources are the following:

- Number of assessments (tests) written;
- Teacher perception of school climate;

- Class size;
- School resources/infrastructure;
- Has the teacher specialised in Mathematics?
- Teacher experience;
- Level of education;
- School socio-economic status;
- Resource shortages in the school;
- Working conditions in the school;

In the HLM analysis the factors mentioned above form part of the second level of the analysis. The methodology followed to respond to the first research question has been applied to the second research question. This research question was answered by creating ten models, one for each covariate (level-2 variable) and a final one for all significant covariates. These models were created using the final level-1 model (model 14) as the base.

Table 4.24 provide the details of the HLM analysis for models 15 to 24 (the level-2 school level variables) and the section that follows provides a detailed analysis of only the variables that were significant. All insignificant variables have been high-lighted in the table. Variables found to be insignificant are the following:

- Frequency of assessments written with a p-value = 0.927
- Class size (fewer than 30 learners) with a p-value = 0.342
- Class size greater than 40 with a p-value = 0.121
- Teacher experience (number of years of teaching) with a p-value of 0.064, which is only marginally insignificant
- Mathematics specialisation with a p-value of 0.211
- Teacher qualification with a p-value of 0.642

Model 16 which is teacher perception of school climate is significantly related to Mathematics performance (p-value = 0.009; SE = 3.39). The average Mathematics score is 346.60 which is very similar to the average observed in the unconditional model. Where teachers perceive the school to have a good climate learners score 9 points higher than their counterparts. Table 4.24 shows that there is a significant difference (p-value = 0.001; SE = 13.33) in Mathematics scores between learners who belong to a school with a high socio-economic status and those in low SES schools with learners in High SES schools obtaining 46 points higher than learners in low SES schools.

Another important and significant variable to mention is school infrastructure. This variable encompasses the physical infrastructure like school classrooms, library, etc. School infrastructure has a significant effect on learners' Mathematics performance (p-value = 0.002, SE = 4.30) and Table 4.24 shows that learners in well-resourced schools score on average 14 points more than learners from schools with no or very little infrastructure.

A very similar pattern is observed when looking at working conditions where the impact is negatively associated with performance. For this variable learners whose teachers say they experience problems, whether minor or moderate, score almost 69.4 points lower Table 4.24) than those who indicated that they experience no problem or hardly any problems in their working environment.

Teachers were asked about resource shortages they experience at school. This variable is significantly related to Mathematics performance (p-value = 0.013; SE. = 31.37). Table 4.24 shows that Mathematics performance is negatively associated with resource shortages, indicating that learners in schools that are not affected by resource shortages score on average 78 points more than learners whose teachers say that shortages are experienced.

Table 4.24: Level 2 models (Model 15 to 24)

Model	Parameters	Estimates	SE	P-value
15	Intercept (assessment monthly was reference category)	343.37	11.44	0.000
	Assess	1.72	18.52	**0.927**
16	Intercept	346.60	8.07	0.000
	School Climate	9.00	3.39	0.009
17	Intercept (High SES was reference category)	319.29	5.24	0.000
	School SES	45.93	13.33	0.001
18	Intercept (Class size less than 30 was reference category)	373.82	30.36	0.000
	Class Size 31 - 40	-30.68	32.19	**0.342**
	Class Size >40	-47.88	30.82	**0.121**
19	Intercept	183.27	47.47	0.000
	Infrastructure	13.54	4.30	0.002
20	Intercept (1-5 years was reference category)	363.02	5.60	0.000
	Teach Experience	-11.52	6.20	**0.064**
21	Intercept (No specialisation was reference category)	364.30	5.17	0.000
	Maths Specialisation	22.73	18.11	**0.211**
22	Intercept (Matric or diploma was reference category)	334.66	26.35	0.000
	Teacher Qualification	5.50	11.83	**0.642**
23	Intercept (affected a lot was reference category)	424.23	36.29	0.000
	Resource Shortages	78.33	31.37	0.013
24	Intercept (serious problems was reference category)	453.64	26.94	0.000
	Working Conditions	69.43	14.48	0.000

Table 4.25 shows that the teacher's working conditions show the most variance between schools (38%), followed by infrastructure (22.45%), school climate (17.69%), resource shortages (17%) and lastly by school SES (13.33%). Variables like class size, teacher experience and Mathematics specialisation contribute very little in comparison to the variables just mentioned. The within school variance is explained by the level-1 model and hence Table 4.25 shows no variation.

Table 4.25 : Variance: Individual level-2 models and final level 1 model (model 14)

		τ00 Variance between schools	**σ2 Variance within schools**	**τ_{00} (between) %**	**σ^2 (within) %**	**Total Variance explained %**
Model 14	Mod 14	5283.08	2620.36			
Assess	Mod 14 vs. Mod 15	5303.55	2620.36	0.39	0	0.39
School Climate	Mod 14 vs. Mod 16	4348.58	2620.12	17.69	0.01	17.7
School SES	Mod 14 vs. Mod 17	4579.04	2620.48	13.33	0	13.33
Class Size	Mod 14 vs. Mod 18	4934.23	2620.38	6.6	0	6.6
Infrastructure	Mod 14 vs. Mod 19	4096.97	2620.34	22.45	0	22.45
Teacher Experience	Mod 14 vs. Mod 20	5148.84	2620.31	2.54	0	2.54
Mathematics Specialisation	Mod 14 vs. Mod 21	5148.84	2620.31	2.54	0	2.54
Teacher Qualification	Mod 14 vs. Mod 22	5286.89	2620.37	0.07	0	0.07
Resource Shortages	Mod 14 vs. Mod 23	4374.09	2620.19	17.21	0.01	17.22
Working Conditions	Mod 14 vs. Mod 24	3277.21	2620.19	37.97	0.01	37.98

The final model (model 25) provides the final level-2 significant variables that remained in the model after the insignificant factors were removed. Table 4.26 shows that teachers' working conditions have the greatest impact on schools. Learners whose teachers said there were hardly any problem at the school scored on average 51.8 points higher than those learners whose teachers stated that moderate problems exist.

This is followed by a teacher who has specialised in Mathematics while studying. Learners who are taught by teachers who have specialised in Mathematics scored on average 26 points more than learners who are taught by teachers who have not specialised in Mathematics.

School SES also has a significantly positive effect on learner Mathematics performance with learners from high SES schools out-performing those from low SES schools by 23 points.

Infrastructure showed a significant positive effect on learner Mathematics performance but the impact is not as large as in the variables just mentioned. Learners in well-resourced schools scored 7.36 points more than learners from poorly resourced schools.

Table 4.26: Final Model (model 25)

Model	Parameters	Estimates	SE	T-ratio	d.f.	P-value
25	Intercept	349.76	35.50	9.85	249	0.000
	School SES	23.00	9.63	2.39	249	0.018
	Infrastructure	7.36	2.49	2.95	249	0.004
	Maths Specialisation	26.24	9.29	2.82	249	0.006
	Teacher working conditions	51.84	11.71	4.43	249	0.000

When comparing the variance explained, model 25 elucidates 47.89% (see Table 4.27) of the variance between schools; however, no additional variance is explained within schools.

Table 4.27: Variance explained by model 14 (level-1) and model 25 (level-2)

	τ_{00} Variance between schools	**σ^2 Variance within schools**	**τ_{00} Variance between schools (%)**	**σ^2 Variance within schools (%)**	**Total Variance explained (%)**
Model 14	5283.08	2620.36			
Model 25	2752.95	2620.23	47.89	0.0049612	47.90

The model indicates that learners who are most successful in learning Mathematics tend to attend schools with adequate infrastructure and teachers who are satisfied with their working conditions. The model suggests that addressing these issues by improving the infrastructure and working conditions of disadvantaged schools would likely reduce the variation among schools in their learners' achievement levels by over 40 percent.

4.4 Summary

This chapter provides the details of the data analysis performed as well as the findings. All the results have been discussed in terms of the two research questions. In addition all HLM assumptions were tested and abided by. The final chapter provides topics for discussion and recommendations as well as concluding remarks.

Chapter 5

5 Discussion and Conclusion

5.1 Purpose

Since the inception of the MDG with respect to education, attention in developing countries has been focused on universal access to basic education for all learners aged 7 to 15. With access being the focus in the post-apartheid South Africa, less attention has been paid to the quality of education received by learners who now have access to schools. The Government realised that quantity and quality cannot be separated and regarded as independent entities; hence great strides have been taken to ensure that learners receive quality education.

Research has shown that factors that affect educational quality are by no means independent of one another; there are learner home factors that affect learner performance; similarly factors within the school or classroom affect learning and performance. Only when these factors are seen as the complex-web that it is, will issues of school quality be resolved.

The purpose of this study is to determine the learner home and school background factors that affect learner Mathematics performance. The analysis employed simple descriptive and multilevel models on the South African data from the 2011 TIMSS to determine a set of school and classroom factors that are associated with school quality. In the previous chapter the analysis of the findings was presented. In this chapter the major findings in relation to the research questions posed earlier are presented.

5.2 Results

5.2.1 Unconditional model: to what extent do schools differ regarding their learners' achievement levels?

The results from the HLM unconditional model show that the variance explained by Mathematics performance between schools is 0.62 or 62%. This means that the differences in the quality of the schools learners attend account for about 62 percent of the variation in their achievement levels in Mathematics. This indicates that large variations exist between schools that could be a result of the apartheid system prior to 1994. In the apartheid era schools were divided into racial departments where resourcing and funding was dependent on the racial department a school belonged to (Motala, Dieltiens, & Sayed, 2009; Reddy, Buhlungu, Daniel, Southall, & Lutchman, 2006). History has shown that schools that formed part of the previously white racial departments were generally better resourced than schools designated as "previously black" schools (Motala et al., 2009). Judging from the variance explained it would seem that South African schools are still largely unequal. Research has shown that in developed countries schools are more homogenous and that differences occur more within schools than between schools. This is not the case in South Africa; where research done using the TIMSS 2003 data has shown that the variance explained between schools is 76% (Phan, 2008). Our estimate for 2011 is 62% indicating a potential drop of 14%, from 2003. More research is needed to determine if this drop is associated with concerted effort of the post-apartheid education policies to improve the resource situation of the previously disadvantaged schools.

5.2.2 Research question 1: learner characteristics associated with quality

The first research question refers to the extent to which Mathematics performance is associated with factors relating to the learners' home background like age, racial group, family structure and family SES. Variables considered here are comparison of the test language to that of the home language, adult involvement in aspects of learning, the learners' perception of school climate, as well as their attitude towards Mathematics.

Learner age has been included in the study because research has shown that there is a relationship between learner age and learner performance. In South Africa the grade appropriate age at Grade 9 is between the ages 14 and 16 and for purposes of the current study, the age variable was dichotomised to create 3 separate variables. The first group included learners' aged 10 to 13; the second were learners aged 14 to 16 and the third group were learners older than 17 where the

14 to 16 year old group was used as the reference group. The results show that there is no significant difference in the mean Mathematics scores between ages 10 to 13 and the ages 14 to 16, which concurs with the findings of (DeMeis & Stearns, 1992). The opposite, however, is true for the older (over-age) learners, in that there is a significant difference in average Mathematics performance between learners who are over-age (aged 17 and older) and those who are the appropriate age for Grade 9. This is a negative difference and the results show that over-age learners score 21 points lower than grade appropriate learners. There appears to be some contradiction in research findings with regard to age, with some studies finding no significant difference in age and learner performance (Kunje et al., 2009). Other studies have found that a significant linear relationship exists between age and performance and that over-age learners perform better than grade-age appropriate learners (Grissom, 2004). However, Grissom states that this linear relationship exists only in the younger grades and that as learners progress to the higher grades this linear relationship becomes a negative one (Grissom, 2004). Studies have shown that the primary cause of over-age (Grissom, 2004) is grade repetition (Department of Basic Education, 2011) and Muller, in 1998 stated that access was no longer the concern but that countries need to find a way to get learners through the education system (Guzula & Hoadley, 1998) .

The analysis also assessed how learners' attitude and confidence affect their success in learning Mathematics. TIMSS used three indices to measure learner attitude toward learning Mathematics. The analysis indicates that learners with positive attitudes obtain higher average Mathematics scores than learners with a negative attitude. Confidence in learning Mathematics has the greatest impact on learner performance with learners who are confident obtaining on average 18.80 points more than learners who say they are not confident. This is followed by learners' liking Mathematics (16.57 points) and learners who value Mathematics scoring on average 6.70 points higher than those who do not value Mathematics. The results are in line with that of research done by Fan, Quek, Zhu, Yeo, Lionel & Lee, 2005 but contradictory to that of analysis done by Mullis and co-researchers in the 1999 TIMSS study where they found that Japanese learners have a negative attitude toward Mathematics but still perform better than learners in many countries that participated in TIMSS in 1999. Some studies have also found no significant relationship between learner attitudes toward Mathematics and Mathematics achievement (Papanastasiou, 2002).

Statements posed to the learner with regard to parental involvement were whether parents enquire about what is learnt at school, whether discussions are held with regard to school work, parents ensuring that time is set aside for learners to do homework and finally parents checking if homework has been done. Parental or adult involvement in the schooling of the learner has been found to be significant in the current study, indicating that an association exists between parental involvement and learner Mathematics performance (Hoover-Dempsey et al., 2005) . Findings by Chiu & Ho (2006), on the other hand, are contradictory in the sense that they found the association between parental involvement and learner performance to be insignificant.

The results, however, show that parents who are involved in the learners' school work on a daily basis have a negative effect on learner Mathematics performance. This is supported by Hoover-Dempsey and co-researchers (2005) who found that parents who are overly involved in the learners school work tend to have a negative impact on learner performance. The results also show that learner performance is better when parents are involved on a weekly basis as opposed to a daily basis.

Bullying seems to be a problem in schools and over the years the percentage of learners who have been bullied has increased. The TIMSS 2011 data shows that 75% of learners have been bullied to some extent (Mullis et al., 2012). Bullying has almost doubled in the past 11 years since the TIMSS 2002 cycle. The percentage of learners who said they were bullied often in 2011 (27.9%) is almost double the figure in 2002 (16%) (Reddy, 2012). The results of the current study show a significant negative effect between the average Mathematics score of learners who are bullied often compared to those who have never been bullied. Furthermore learners who said they were never bullied had a higher Mathematics score on average than learners' who said they were bullied on a weekly basis. This result is in line with Nakamoto and Schwartz (2010) who stated that bullying has a negative impact on learner achievement. Juvonen and Graham (2004) point out that learners' who experience being bullied are at least a grade and a half behind their peers who are not bullied. No evidence has been obtained to contradict the finding of the current study.

Variables considered in the study but that were found to be insignificant are family socio-economic status, family structure, home educational resources and home language same as test language.

In the current study amenities found in the home were used as a measure of family SES. Research has shown a strong association between family SES and learner performance (Sirin, 2005); however, this contradicts the results of the current study that has found no significant difference in the average Mathematics score between learners from high SES and those from low SES households.

The results further show that there is no significant association between the average score of learner's from 2-parent households and those from another household structure. Research conducted by (Amato & Keith, 1991) found that learners from single parent households as well as learners in a 2-parent home (due to remarriage or co-habitation) had lower achievement levels than learners from pure biological 2-parent (nuclear parents) households. Research done by Entwisle and Alexander (1990), however, supports the results of the current study that has found that family structure has no effect on learner performance in the secondary years of schooling.

Home educational resources in this study are a composite measure that includes information of the number of books in the home, the highest educational level of either parent, whether the learners have an own room and lastly whether they have access to the Internet at home. The results show no significant association between Mathematics performance and educational resources in the home, which concurs with research done by Stafford in 1980. Stafford divided educational resources into two inputs, namely time input and goods input. Goods input refer to facilities made available in the home to support learning and time input refers to parental involvement in assistance with school-related matter such as homework. Stafford found a significant relationship between time input and performance but not with goods input, which is in line with the findings of the current study.

The comparison between the home language and the test language or language of instruction has caused massive debate with researchers and educationalists saying that an increase in learner performance is observed when the language of test is the same as the home language (Heugh, 2005). Heugh believes that it is vital that learners are taught in their home language for the duration of the primary school (Grades 1 to 7); this is supported by Fafunwa, Macauley, and Sokoya (1989) who found that learners taught in their mother tongue for the first six years of schooling obtain higher results than those taught in purely English. Results from the current study show no significant difference in average Mathematics scores between learners whose home language and test language is the same and those where the languages differ. Research has found that the mother tongue effects on performance are more pronounced in the lower grades and not so much in the higher grades (Maree et al., 2006). This could possibly explain the results from the current study.

5.2.3 Research question 2- school characteristics associated with quality

The second research question refers to the extent to which Mathematics performance is associated with contextual factors relating to the school. The ten contextual factors considered are how often the teacher does class assessments, the teachers' perception of school climate, school SES, class size, infrastructure, teacher working experience, teacher qualifications and specialisation in Mathematics, resource shortages experienced at the school as well as teachers' working conditions. This section of the discussion provides information on factors from the most significant to those least significant.

The school contextual factor that seems to have the most marked impact on learner Mathematics performance is the teachers' perception of their working conditions at the school. Teacher working conditions can adequately be described by four school resources which, when adequately provided to the school, would result in improved working conditions for the teacher (Johnson, 2006) . These are adequate physical conditions (buildings), an orderly environment (school climate), instructional resources (textbooks and blackboards) and reasonable workloads (Johnson, 2006).

In the current study the “teacher working conditions” measure is composed of statements that the teacher had to respond to regarding the condition of school buildings, overcrowded classrooms, too many teaching hours, inadequate space and instructional material. The results show that learners in schools where teachers report the working conditions to be poor score on average 52 points lower than learners in schools where teachers report having hardly any problems with regard to working conditions. This finding is in line with that of Firestone and Pennell (1993) who found that a lack of instructional resources relates to poor working conditions and hence poor academic achievement.

The results show that learners whose teachers have specialised in Mathematics score on average higher (26 points) than learners whose teachers did not specialise in Mathematics during their post-school qualification; this result is supported by Goldhaber & Brewer (2000). Rowan and co-researchers (1997) stated that learners who are taught by teachers who specialise in Mathematics education or pure mathematics obtain higher scores than those learners who were taught by teachers who had not specialised in the subject.

School socio-economic status is the third most significant school level measure and includes variables like the density of the population surrounding the school, whether the community is economically affluent or not and what the average income level of households in the area surrounding the school is. The results show that learners in schools that are categorised as high SES schools obtain a score that are on average higher than learners from low SES schools. The score difference between these learners is 23 points. This is in-line with findings by Willms and Somer (2001) as well as that of Ma and Xu (2004) and Ma and Klinger (2000).

School infrastructure in the current study refers to school resources like textbooks, stationery, school building, black boards and classrooms. The results show that learners in well-resourced schools perform better than learners from schools that are not well-resourced. This is supported by Fuller and Clarke (1994) who suggest that the most significant positive learning relationship with learning outcomes is the availability of textbooks and reading material. Research has shown that in developing countries the resources or infrastructure has a larger impact on performance than variables pertaining to school organisation and instructional variables (Scheerens, 2000) . This, however, is contradictory to what happens in developed countries where the impact of school organisation and instructional variables has a greater impact.

The school level variables found to be insignificant are those of the number of assessments/tests completed, school climate, class size, and teacher qualification and experience.

Schiefelbein and Simmons (1981a) reviewed 32 different studies of the school effect on learner performance and found that learners taught by qualified teachers did not perform significantly better than learners who were taught by un- or under-qualified teachers. The results of the current study support this finding. Hanushek (1995) however, disagrees and states that teacher education and experiences positively affect learner performance.

Although class size proved to be insignificant in the current study it is important to note that larger class sizes, classes with more than 40 learners, were associated with lower mathematics scores. This finding was supported by Steward in 2008Fuller and Clarke (1994) found no significant correlation between class size and learner performance which is in line with the results of the current study.

School climate refers to a school's beliefs, values and communication between learners, teachers and administration. When school climate was added as a single variable in the HLM analysis it was found to have a positive significant relationship with learner performance, indicating that learners in schools with an acceptable school climate perform better than learners from schools with an unacceptable climate. However, with the inclusion of the remaining school level variables the school climate variable became insignificant. This could be due the school SES variable being included in the model. Research has shown that generally well-resourced high SES schools are linked to an acceptable climate (Corcoran et al., 1988).

5.3 Limitations

The current study is a secondary analysis; hence it limited to the data collected. For instance, information like the number of siblings in the home was not asked, and research has shown that parental involvement is higher with fewer children in the home, a fact that could also have an impact on learner performance. The question on who assists the learner with homework was not asked; for this study the focus is more on adult involvement than it is on parent, sibling, and grandparent and possibly aunt/uncle that assist with homework, which is also known to be a factor to consider when looking at learner performance. School infrastructure with regard to running water, electricity and operational ablution facilities were not asked as a lack of these facilities could lead to poor school climate and hence have a negative impact on learner performance.

Because the questionnaire information was contextual and based purely on perception, participants (learners, teachers and principals) could over- or under-report information. This could lead to information bias.

In this study mathematics was used on its own to measure learner performance and perhaps in the future a broader definition of performance could be explored.

5.4 Recommendations

A problem that the Education Departments in South Africa faces is the large percentage of learners who repeat grades. The results of the current study shows that 53% of Grade 9 learners are over 16 years of age; reasons for learners' repeating grades could be schooling interruptions, the appropriate academic support not given to the learners' and school changes. A suggestion is that these over-age learners be assessed to determine if any psychological, emotional or social inabilities exist, and based on the outcome, decisions be made about what the best solution would be for the learner. These options could include extra lessons to enable the learner to catch up and the possibility of the learner exiting the school system after successful completion of Grade 9 and possibly entering an FET college. Research has shown that there is a great demand for skilled labour. The Department of Education has to develop an early warning system that will identify learners who could possibly become over-age. Parents also need to be made aware of options available to their over-age learners.

Research has shown that parental involvement is vital in the development of the learner; providing the learner with facilities in the home for school work is not good enough and interaction between parent and child is more important. In fact, what seems to have a greater impact on learner performance is parental involvement in matters of the learner's school work and not the educational resources found in the home. Schools need to make a point of keeping parents informed of the progress of their children and possibly provide advice that would assist the parent in providing adequate support to children. Parents need to be alerted to problems encountered in the school so that measures are put in place to address them.

Research has found a strong link between school climate and bullying. In schools where a good climate exists, the rates of learners being bullied are lower and hence the school results are better. Schools need to put measures in place that will enhance the climate of the school and this should result in a decrease in the amount of bullying that occurs at school. Bullying is a cause for serious concern in schools and should not be taken lightly by school staff. A recommendation thus is to improve the climate of the school and this will lead to a reduction in bullying rates.

Learners' attitudes toward Mathematics are extremely important and have a positive effect on their performance; learners with a positive attitude toward Mathematics perform better in the subject. However, a learner's positive attitude is directly linked to the teachers' attitude toward teaching Mathematics. For learners to enjoy Mathematics it is important that educators have the same positive attitude as well. The attitude to Mathematics is linked to how confident the educator is to teach it. The current study has shown that learners whose teachers specialise in Mathematics while studying perform better than those taught by teachers who did not study Mathematics as subject.

School SES, infrastructure and teachers' working conditions are interlinked; usually high SES is linked to no infrastructure problems and teachers have no problems with their working conditions. The Government has made great strides in reducing inequalities between schools by providing school with physical resources. However, it seems that South Africa is far from closing the inequality gap completely and more effort should go into repairing buildings, finding a way to reduce overcrowded classes and providing adequate workspace for teachers. This will contribute to teacher satisfaction with working conditions that should lead to an improved school climate; in turn this will result in improved learner performance and hence improved school quality.

In conclusion it has to be stated that the Government has made great strides in reducing the measure of inequality that was caused by the apartheid era. After 1994 the Government devised a poverty quintile system in which schools are ranked depending on their poverty status. The quintile takes issues like the socio-economic status of the area surrounding the school as well as the infrastructure available to the school into account and places schools on a scale from 1 (very poor) to 5 (very wealthy). Based on these rankings the Government has created policies to ensure that the three lowest quintiles are provided with additional resources.

When adding race to the level-1 model the results show that the difference in learner Mathematics scores on average is close to 12% (see Table 4.21). However, when the other level-1 variables are included the race variable becomes insignificant. What this implies is that if adults were involved in their children's homework on a weekly basis, if learners were not bullied, and if they liked, valued and were confident in learning Mathematics, race would not matter.

Similarly at school level the SES of the schools is highly significant with the difference between learner scores relating to low and high SES schools being exceptionally high. Learners in high SES schools score on average close to 46 points (see Table 4.24) more than learners in low SES schools. With the addition of the level-2 variables however, this difference drops to 23 points (see Table 4.26) which is half the original difference. This means that if the Government focused on supplying poor schools with infrastructure, ensured that the teachers teaching Mathematics were specialised in the field and lastly improved the working conditions of teachers within schools, an improvement in learner scores would be observed which would result in improved quality.

When considering the "Action plan to 2014, towards realisation of schooling 2025" that was drafted by the Department of Basic Education this study could assist the Government in improving the quality of Mathematics education in schools.

Of interest for future studies would be the comparison between South Africa and other TIMSS countries of similar economic stance to South Africa.

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