



**DETERMINANTS OF STUDENT ACHIEVEMENT IN BOTSWANA, SOUTH  
AFRICA AND ZIMBABWE:**

**A MULTILEVEL APPROACH**

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*[Specialising in Economic Development]*

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## Abstract

An educated population has significant advantages relative to an uneducated one, since education has a high economic and social payoff. However, in the education process, scholars are not in agreement on which factors better explain student achievement. Some argue that school resources are key determinants, whereas other scholars maintain that factors outside the school better predict student achievement. Even within these sentiments, there are arguments on which school-level, classroom-level or student-level variables better explain achievement. Knowledge of such factors is critical, as it helps stakeholders to devise strategies that improve student success. It also helps to maximise budget allocations and at the same time gets the most out of per dollar expenditure.

This study has used data from the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ III) to estimate the determinants of student mathematics achievement in three developing countries in Southern Africa; namely, Botswana, South Africa and Zimbabwe.

A three-level Hierarchical/Multilevel Linear Model was employed in this analysis. The study found three generic factors that explained student achievement in all the countries under study: speaking the instructional language, coming from a family in the top half of SES, and school resources. Additionally, other factors considered in the research had different effects across countries, not only in terms of significance but also in terms of coefficient signs and magnitudes.

Regarding coefficient size, it was realised that student-level factors were more important in explaining student achievement, relative to school and classroom-level factors. These results hence led to the conclusion that it is inappropriate to simply assume that the same factors that explain student achievement in one country apply in another country without empirically testing them. Additionally, the method of estimation was seen to greatly influence results, thus care should be taken in choosing the appropriate method of estimation.

The multilevel model used enabled the researcher to assess how much of the variance was explained by each level, and it was discovered that these differed per country setting, with South Africa exhibiting higher between-school variance, indicating a high inequality across schools – a reflection of its racially unequal society. We suggest that it is important to take into account the background of the students, their classroom and the school processes in designing policies to better improve student achievement.

**KEYWORDS:** Determinants, Student Achievement, SACMEQ III, Hierarchical Multilevel Linear Model.

## **Acknowledgements**

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I thank the Staff Development Committee at the National University of Science and Technology, Bulawayo, for availing me the rare opportunity of funding my studies. I appreciate the support given me by the staff at the Institute of Development Studies at NUST, as well as the School of Economics at UCT. Last but not least, I would like to express my gratitude to my family for being there for me when I needed them the most.

## **Dedication**

This thesis is dedicated to my late father Titus Dulula Ndlovu

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# **Chapter One**

## **Introduction**

### **1.1 Research problem**

It is widely agreed that quality education plays an important role in a person's life opportunities, their standard of living, and in a country's economic development and growth prospects (Day & Newburger, 2002; Ilie & Lietz, 2010; Hanushek & Woessmann, 2010). Therefore, an educated population has significant advantages relative to an uneducated one, since education has a high economic and social payoff. Having observed such potential effects of quality education, various stakeholders have invested significantly in education, both financially and materially, in an effort to improve access to education. As a result, countries have seen a significant increase in student enrolment, specifically in primary schools. But there has not been a similar trend as far as achievement is concerned. This has made countries realise that mere attendance does not translate to achievement.

This calls for an investigation into the factors that determine student achievement. Establishing these determinants will aid policy formulation and effective strategy development towards improving student achievement. This is particularly important in developing countries battling to find ways of catching up with the developed world in various areas such as standard of living, quality of life, economic performance and development. The literature offers inconclusive evidence on what could be the best formula to enhance student achievement in developing countries' schools (Glewwe et al, 2011) hence; more analysis is needed to explore how student achievement can best be improved.

Such inconclusive evidence across both space and time on what determines student achievement has resulted in contrasting policies being tabled and implemented in a bid to improve student attainment levels, albeit with mixed results. Some have argued that increasing the quantity and improving the quality of school resources is the panacea for student achievement (Afana, Lietz & Tobin, 2013; Lee & Zuze, 2011; Greenwald, Hedges & Laine, 1996; Case & Deaton, 1999; Heyneman & Loxley, 1983). These research findings have persuaded some policymakers to fund the purchase of various school resources such as textbooks, chairs, desks, teachers, and to improve student-teacher ratios, with the hope of increasing student achievement.

However, some studies stemming as far back as the seminal paper by Coleman et al, (1966), have argued that school resources have no effect on student achievement and thus investing in school resources would not necessarily improve student achievement, whereas factors external to the school may have an effect on achievement. The Coleman report claimed were further confirmed by Hanushek (1986; 1989; 1997) in a series of meta-analyses, and by other subsequent papers over the years such as Baker, Goesling, and LeTendre, (2002), Ehrenberg et al, (2001) and Rumberger and Palardy (2004). Other studies have argued that the effect of school resources is determined by the economic well-being of a country. They state that school resources are more important in developing countries relative to those that are economically developed (Heyneman & Loxley, 1983), whereas others claim that the very vulnerable in those poor countries need more resources to succeed (Case & Deaton, 1999).

Such mixed findings leave policymakers and other stakeholders with no sure policy prescription towards the improvement of student achievement, as it seems there is no “one size fits all” policy. All these efforts stem from the understanding that quality human capital is a fundamental ingredient to a country’s economic and social well-being. Thus the fact

remains that a country still needs to focus on improving student achievement for it to benefit from quality human capital.

## **1.2 Purpose of the study**

This study therefore sought to estimate the determinants of student achievement in three neighbouring countries in Southern Africa. Specifically, the study focused on mathematics achievement amongst Grade 6 pupils in Botswana, South Africa and Zimbabwe, using SACMEQ III data. This is a rich dataset with student, classroom, and school level information. The present study intended to ascertain factors that affect student maths achievement in primary schools, and the extent of the variability between and within schools in the three countries. It then compared and contrasted these findings between the countries under study.

In order to meet the research objectives, the research attempted to answer the following questions:

- ❖ Which student, school and classroom-level variables significantly explain student achievement in the respective countries?
- ❖ How is the variability in maths achievement of Botswanan, South African and Zimbabwean Grade 6 pupils distributed within classrooms, between classrooms, and across schools?
- ❖ To what extent is the variation in maths achievement explained by the selected covariates?
- ❖ Are the same factors influencing student achievement in these neighbouring countries?

## **1.3 Contribution of the research**

This research seeks to assist policymakers to formulate policies that effectively improve student achievement, considering that national budgets are usually constrained in adequately

equipping all schools, and that education ministries compete with other ministries such as the health ministry, for the same dollar of government revenue. This research will thus enable governments to efficiently allocate their resources and achieve the much needed quality of human resources. In their meta-analysis of trying to ascertain which school and teacher variables have an influence on student achievement, Glewwe et al, (2011) reached the conclusion that having a fully functional school well equipped with quality physical and human inputs, significantly improved student achievement. However, because of resource constraints, not all countries are in a position to fully furnish their schools with all these prerequisites, particularly those still developing.

This research, therefore, is useful when establishing those resources that are more influential in determining student achievement, so that they can be prioritised. The aim is to ascertain the most binding constraints in student achievement, thus facilitating policymakers to make more informed decisions on which areas to prioritise for educational outcomes improvement, while considering that their budgets are constrained. This study does not in any way negate the importance of the Glewwe et al, (2011) recommendations, but it takes a piecemeal approach to fulfilling such recommendations, considering that developing countries are resource constrained and cannot fully cater for all necessary resources in one budget.

#### **1.4 Organisation of the rest of the thesis**

To achieve the research objectives, the rest of the paper is structured as follows: the following chapter describes and compares the education systems in the countries under study. It shows their historic and economic contexts, and their primary students' performance over time. The third chapter reviews related literature, with the intention of bringing out the direction and concerns in the educational achievement discourse around the world. Additionally, the third chapter discusses the different methodologies employed in the literature, reviewing their



strengths and weaknesses. This is important as it assisted the researcher in choosing the appropriate empirical approach for this research. Informed by the discussion in Chapter Three, the fourth chapter outlines the research methodology. It discusses the population, the sample, variables to be employed, the estimation method and the assumptions underlying the methodology chosen to estimate the determinants of student achievement. The penultimate chapter presents and discusses the research results, while the final chapter contains the conclusions and recommendations based on the research findings.

## **Chapter Two**

### **The Study Setting**

#### **2.0 Introduction**

To set the stage for the rest of this paper, this section presents a general overview of the countries under study. The purpose of this situational analysis is to gauge the problems that these countries are currently facing in trying to attain education for all, and at the same time maintaining high achievement levels.

#### **2.1 Socio-Economic Context**

South Africa, Botswana and Zimbabwe are neighbouring countries in Southern Africa. Being neighbours, the three countries under study share a similar cultural heritage. The reason being that before colonialism, which partitioned them with strategic political boundaries, these countries had their own territorial boundaries which were mostly demarcated by kingdoms. Thus to this day, it is not surprising to find that most communities along their borders speak the same language, and some are related. These countries also share a colonial history, as they once were British colonies. Comparing the three countries under study, in the year 2014, South Africa had by far the highest population at 54 million people, followed by Zimbabwe at 14.5 million and lastly Botswana, with a low population of 2 million inhabitants (World Bank, 2015). In terms of population distribution, in 2014, more than two thirds of Zimbabwe's population resided in the rural areas, compared to 42% in South Africa and 36% in Botswana.

South Africa and Botswana are classified as upper- to middle-income countries, whereas Zimbabwe is classified as a low-income developing country. GDP per capita (current US\$) for the three countries as of 2014 was US\$7 757.03 in Botswana, US\$6 477.86 in South Africa

and US\$935.89 in Zimbabwe (World Bank. 2015). In terms of income distribution, Botswana and South Africa are amongst the most unequal countries in the world, and Zimbabwe has a modestly lower inequality.

## **2.2 Primary Education Systems**

Primary education in the three countries spans across seven years, and is compulsory in South Africa and Zimbabwe. Prospective primary school entrants undergo pre-primary education to enhance early stimulation and development from the ages of three to six years (Masole, 2011). In South Africa and Zimbabwe, students commence primary education in the year they turn seven. In Botswana however, private schools normally accept five-year-olds, whereas public schools accept six-year-olds into standard one (Masole, 2011). English language is the language of instruction in all of the countries under study, though South Africa has Afrikaans as an alternative. Also in South Africa, students learn in their mother-tongue for the first three years of primary school (Grades R-3); thereafter they switch to either English or Afrikaans for the remainder of their schooling career (Grades 4-12) , whereas in Zimbabwe and Botswana, children start learning in English as early as pre-primary education.

At the end of their primary schooling, students sit for national examinations, and a certificate for successfully completing primary education is awarded. The exam results do not normally hinder a student from proceeding to secondary level, though the quality of the results determines the quality of school one can enrol in, as some secondary schools select students based on the quality of these results (Kanyongo, 2005; Thobega, 2015). These results are a strong indicator of the academic ability of a student being sent to secondary school. In

Botswana, primary students also write a national exam in their fourth year, which must be passed in order to proceed to upper primary school (Monyaku & Mmereki, 2010).

### **2.3 Cost of Schooling and Financing of Education**

The government of Botswana abolished fees in 1980 after realising the need to increase access to all children (Masole, 2011). The education sector thus relies on the government, donor agencies and other development partners for its infrastructure, equipment, teaching and learning resources. The government allocates a large share of its national budget to the education sector, averaging 19% per year. In some years it has gone higher than that, for example, a share of 28% and 23.3% was allocated to the education sector in the 2002/2003 and 2009/10 financial years, respectively. Recurrent expenditure on education has been averaging 28% of the total recurrent expenditure budget from the 2007/8, 2008/9 and 2009/10 financial years (Monyaku & Mmereki, 2010; Botswana Federation of Trade Unions, 2007).

Despite enjoying a large portion of the national budget, the education sector can hardly afford to meet all its needs, hence the donor community and other development agencies assist in providing supplementary resources (Botswana Federation of Trade Unions, 2007). Additionally, over the years, some schools have introduced minimal levies such as sports and development levies, in order to supplement the funds allocated to them. However, parents who cannot afford these are exempted (Monyaku & Mmereki, 2010).

Similarly, basic education in Zimbabwe is mainly financed by the government though district councils and town councils; churches, mines and farms also contribute through various means, especially to schools that they are in charge of (International Bureau of Education, 2006). Primary education is valued considerably in Zimbabwe, such that in past years it has been allocated the lion's share in the national education expenditure budget. The Ministry of Education Sports and Culture of Zimbabwe (2013) stated that in 2011, primary education accounted for nearly half of public spending on education, followed by secondary education at 25%, tertiary education at 20%, with the remainder funding teacher education and technical,

vocational and administrative costs. According to the Zimbabwe National Statistics Agency (2013), expenditure on pre-primary, primary and secondary education as a percentage of public expenditure grew from 5.4% to 18.6%, whereas tertiary education expenditure has shrunk from 9.8% (2009) to 6.7% (2013). Most of the funds have been spent on employment costs. In 2011 for instance, nearly 90% of government expenditure on education was spent on employment costs, and the remaining 10% was spent on subsidies to government-run schools as a levy/fee substitute for orphans and vulnerable children, building infrastructure, and provision of learning materials (Ministry of Education, Sports and Culture of Zimbabwe, 2013).

This crowding out of non-human resource inputs has resulted in most schools relying on fees and levies to supplement government funds. The Ministry of Education, Sports and Culture of Zimbabwe (2013) states that these funds are estimated to account for as much as 91% of school income (excluding public funding for teachers' salaries). The cost of education in primary schools averages US\$54.00 per annum per student, though it varies widely according to school type and locale. In 2013 for example, rural schools charged an average of US\$19.00 per annum per pupil, whereas urban and private schools charged about US\$472.00 per annum per pupil (Ministry of Education, Sports and Culture of Zimbabwe, 2013). Furthermore, some schools benefit from other sources of funding, such as from Non-Governmental Organisations (NGOs).

The South African government has relied mainly on fiscal policy for the provision of school facilities and study materials in order to reduce the gap between rich and poor schools (Jansen & Taylor, 2003). Private schools, which are white-dominated, still have better facilities because students who learn in such schools are from affluent families who can afford to better fund these institutions.

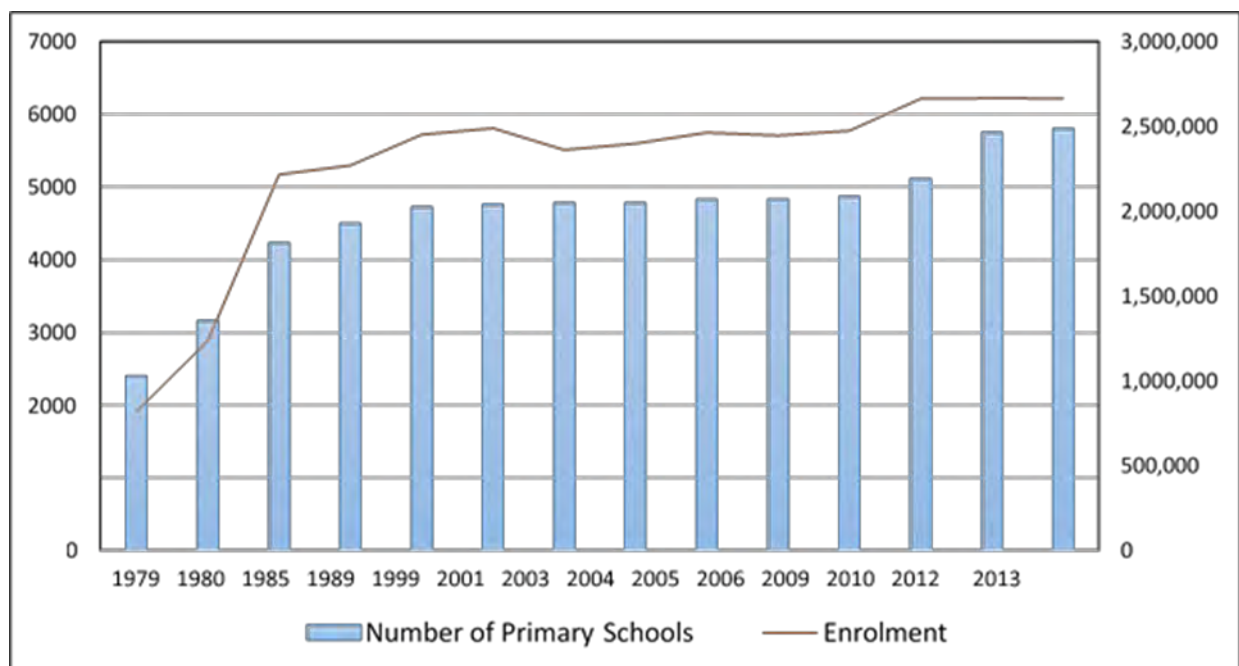
In an effort to ensure universal access to education, the government adopted a no-fee policy in a selection of schools in 2007. In the designated schools, the government compensates for their loss of fee income by subsidy. As a result, the percentage of learners aged five years and older who enrolled at no-fee schools rose from 0.4% of total students in 2002 to 65.4% in 2014. Most of these pupils were from predominantly rural provinces such as Limpopo (92%) and the Eastern Cape (81.5%), whereas largely urban provinces such as the Western Cape recorded 40.7%, and Gauteng had 45.3% (Statistics South Africa. 2015b). Not all schools have been designated as no-fee schools as the government fears that it might fail to adequately fund them and hence affect quality. Additionally, allowing those that can afford fees to pay can be a strategy of unlocking more money from the private sector into public education.

Since the collapse of the apartheid state and the ushering in of democratic rule in 1994 the government of South Africa has kept public expenditure on education ranging from 5% to 6% of GDP. In 1994, as a percentage of GDP, public expenditure was 5.81%; in 2003 it became as low as 4.86%, but as at 2013 it rose to 6% (The World Bank, 2015). An analysis of how expenditure on education is allotted reveals that relative to other departments, primary education in South Africa has had a consistently higher allocation of funds. Throughout the period 1999-2012, more than 40% of public expenditure on education has been spent on primary education (The World Bank, 2015).

## **2.4 Post-Independence Education Policies and Reform**

During colonial rule in the three countries, education provision was mainly along racial lines such that better systems were for the privileged ruling class, and the rest received relatively poorer facilities and access was limited. Post-independence governments in the three countries adopted radical policies aimed at redressing discrimination and exclusion of the black majority in the education system. In 1980, the newly elected government of Zimbabwe

mobilised funds for the reconstruction and addition of infrastructure damaged during the war of liberation. Local communities and rural and urban councils as well as private and religious organisations also took part in support of the government's initiatives (Riddell & Nyagura, 1993). Figure 1 below shows that from 1979, the number of 2 401 functioning primary schools in Zimbabwe had increased to 3 161 by the end of 1980. There were 5 805 functioning primary schools as of 2013. In terms of ownership in 2013, 76% of primary schools were operated by rural district councils, 7% were run by churches, whereas city councils and farms owned 2% a piece. The government owned 5% and the remaining primary schools were under the responsibility of other institutions such as private companies and town boards (Zimbabwe National Statistics Agency, 2014a).



**Figure 1: Number of Primary Schools in Zimbabwe and Student Enrolment, 1979-2013**

Source: Shava (2011); Zimbabwe National Statistics Agency (2014a; 2014b)

Student enrolment also followed an upward trend, as many previously marginalised African children were enrolled in formal primary schools. Figure 1 above shows that the 819 600

students enrolled in primary schools in 1979 rose to 1 236 000 in 1980, and by the end of year 2013, this had increased to 2 663 187. This success led to a demand for more teachers, hence more were trained, resulting in primary teaching staff figures increasing from 28 500 in 1980 to 73 148 in 2013 (Zimbabwe National Statistics Agency, 2014b).

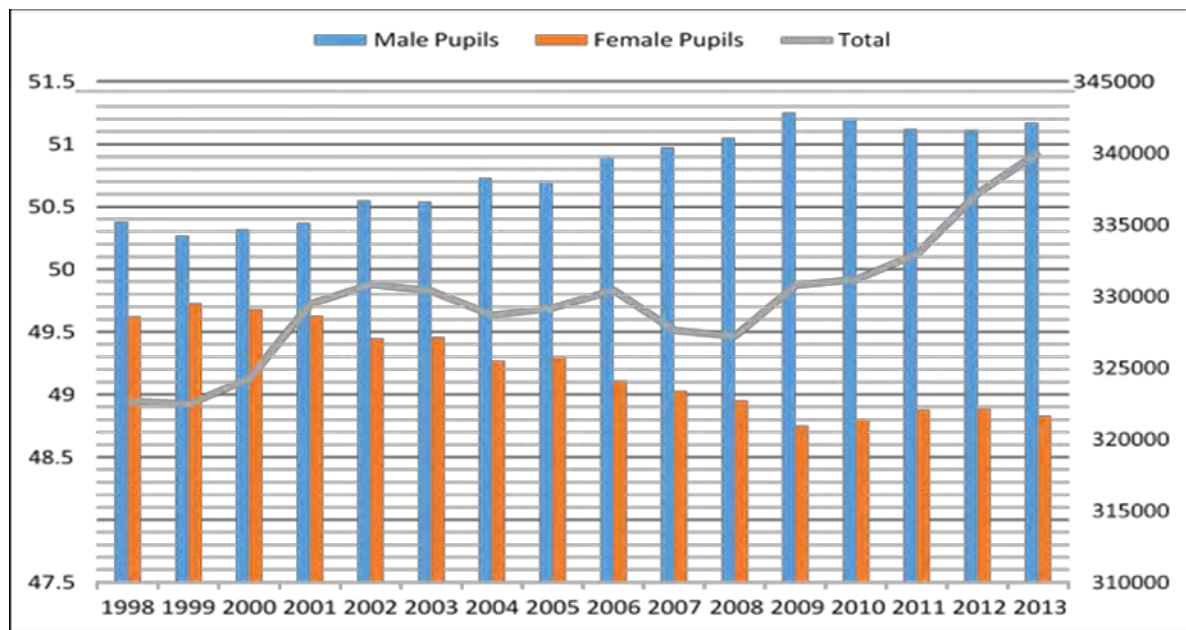
In South Africa, the post-apartheid government abolished all existing racially defined departments of education and established a single education system for all its citizens, as provided for in the South African Schools Act of 1996 (Mouton, Louw & Strydom, 2012). More children, particularly from the previously marginalised races, could now attend school without any hindrance. Data from UIS Analytical Services (2015) reveals that a significant increase in student enrolment was observed soon after independence, and has been maintained for the past two decades.

When Botswana attained its independence in 1966 after almost 80 years under British rule as a Protectorate, it did not inherit economic or human infrastructure as in other former British colonies like Zimbabwe or Kenya (Mosothwane, 2014; Tabulawa, 2013). The education system was not even well developed, as the settler government had relegated this sector to missions and local authorities, which were resource constrained at that time (Tabulawa, 2013). The post-independence government invested heavily in education, and in 1980, it abolished school fees for primary students in an effort to encourage all children to attend school. Abolishing fees led to an exponential increase in student enrolment, as was desired (Mosothwane, 2014).

Figure 3 below presents a change in student enrolment as well as its composition by gender at primary school level in Botswana, for the period 1998 to 2013. It shows that enrolments have been on a gentle increase during this period (from 322 000 in 1998 to 340 000 in 2013). Upon inheriting 251 primary schools at independence in 1966, Botswana has managed to



increase the number to 821 at the end of 2013, (753 public and 68 private schools) (Monyaku, 2013; Statistics Botswana, 2015). In 2013, the government owned 91.7% of primary schools and the remainder were privately owned (Statistics Botswana, 2015).



**Figure 2: Trends in student enrolment in Botswana, 1998-2013**

Source: Statistics Botswana (2012; 2013)

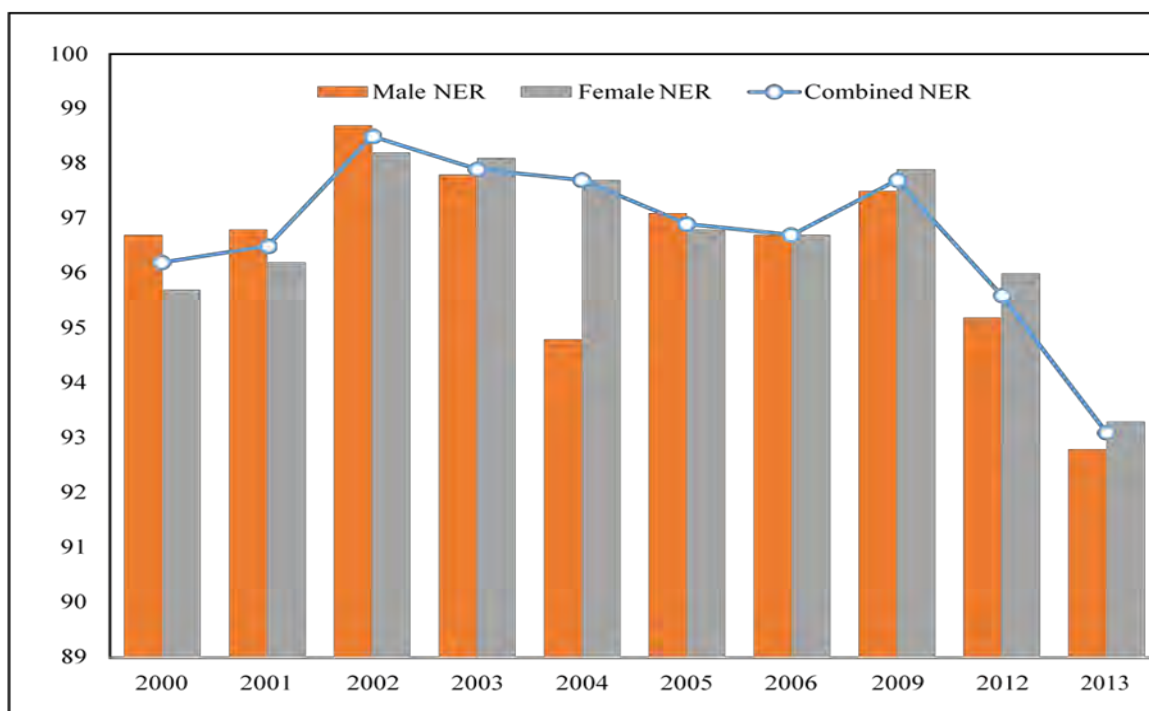
## 2.5 Performance in a selection of Key Education Indicators

The United Nations' millennium development goal of achieving universal primary education by the year 2015 provides indicators that can rate the progress made by these countries in primary education. Key indicators used by the United Nations are the net-enrolment ratio in primary education, the proportion of pupils starting Grade 1 who reach the last grade of primary school, as well as the literacy rate of 15-24 year-olds, women and men (United Nations, 2015). This analysis explores the first two indicators as they are relevant to this research, considering that it focuses only on primary school students.

### **2.5.1 Net enrolment ratio (NER) in primary education**

Net enrolment ratio (NER) is the number of children of official primary school age who have access to primary education as a percentage of the total children of the official school age population. It indicates progress made towards ensuring that all children eligible to attend school have been enrolled. If a country's NER is below 100, it shows that a proportion of primary school-aged children are not enrolled in school.

High enrolment rates have been achieved in Zimbabwe over the years since it attained independence in 1980. The increase in enrolments has been motivated by the government's move to encourage more previously marginalised children to enter into formal education. Policies such as free education, the increased number of schools and a general atmosphere of peace may have been the main drivers. Figure 4 below compares female and male net enrolment rates over a 13-year period in Zimbabwe. It shows that previously, the NER for boys had been higher than that of girls, but this changed after 2006 and the NER for girls is now higher. The probable reason for this could be the emphasis that the government has put on increasing the enrolment of girls that had been marginalised in the past. Though the NER is a useful indicator, it excludes overage/underage children in a given grade, since it only records pupils who are in the correct grade based on their age. This therefore understates the number of children enrolled in a given grade.



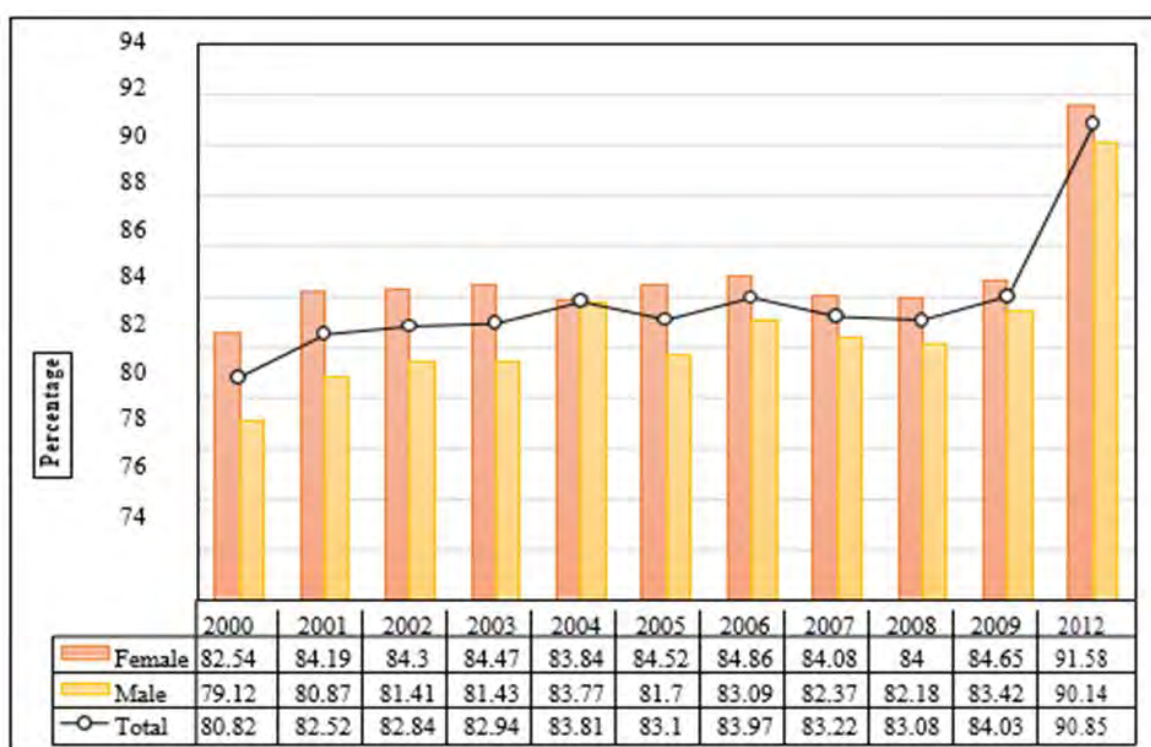
**Figure 3: Zimbabwe's Primary Net Enrolment Rate, 2000-2013**

Source: Munjanganja & Machawira (2015)

South Africa has performed quite well in this regard when compared to the other two countries, even though the country still grapples with racial inequality, 20 years after the end of apartheid. In 2002, South Africa's primary education NER was estimated at 96.7%. These figures have steadily increased such that in 2012 the NER was estimated at 99%, and the 2013 estimate was at 99.2% (Statistics South Africa, 2015a). Data also shows that proportionally, more girls were enrolled in schools than boys. Hence, there were fewer females who were out of the schooling system than boys. South Africa has managed to ensure that almost all children eligible to attend primary education are enrolled in some formal educational system.

Relative to the other two countries, Botswana has recorded lower NER rates in the recent past. Most of the children who are missing out on basic education are located in the remote rural areas, where the value of education has not been well ingrained in their parents; thus they might not be motivated to send their children to school (UNICEF, 2012). Another

contributing factor to such low rates in Botswana could be because some parents prefer sending their children to school only when they have reached the age of seven years; also, some children might already have passed the primary stage, as they could have started in a private school at age five. Figure 5 below is a graph that shows trends in the NER from the year 2000 till 2013. This graph shows that the net enrolment rate has consistently been higher for females than for males over the period 2000-2012.



**Figure 4: Botswana's Primary Net Enrolment Rate, 2000-2012**

Source: The World Bank (2015)

### 2.5.2 Primary completion rates

Overall, student completion rates have now been sustained at high levels in all countries for more than a decade. Though Zimbabwe has been in an economic crisis that presumably should have hindered student attendance and completion, we observed that in 2002, completion rates

were estimated at 89.5%, and in 2008, they were estimated at 98%, with a drop to 91.5% in 2009 and improving in 2012 to 99.5% (The World Bank, 2015). This implies that almost all children who enrol in primary school successfully complete their basic education. In the same period, The World Bank (2015) shows that Botswana started at 92.8% in 2002, and that as of 2012, it was estimated that 97.72% of students completed their basic education. The completion rate in South Africa was estimated at 89.9% in 2002, but has reached 96% as of 2013 (Statistics South Africa, 2015b). When comparing these three countries in this respect, we observe that relatively more students complete primary education in Zimbabwe, followed by Botswana and lastly, South Africa. Thus all countries have performed quite well in this regard.

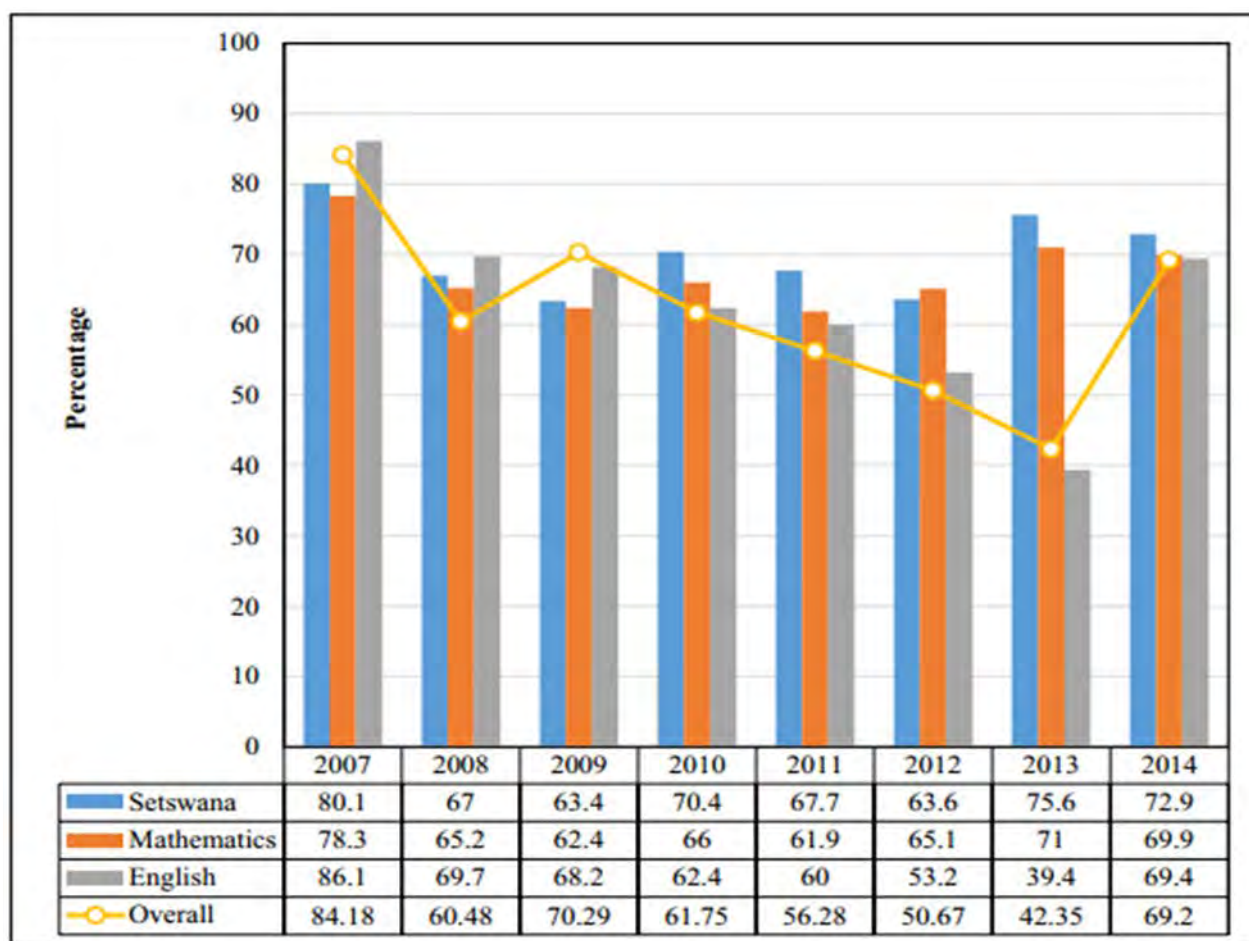
### **2.5.3 Transition rates to secondary education**

Botswana has achieved significantly higher transition rates to secondary schools than the other countries under study. At independence, it was estimated that only 8% of the Standard 7 graduates were able to proceed to secondary education. This figure rose to 34.47% in 1985, to 96.5% in the year 2000, and as of 2014, the transition rate was estimated to be 98.1% (The World Bank, 2015; Statistics Botswana, 2015). This trend shows that the desired rate of 100% is feasible in Botswana.

Historical data for Zimbabwe shows that since the 80s, no significant change has been observed in the proceeding of students to secondary school. The World Bank (2015) revealed that in 1984, 76.69% of all those who completed primary education managed to proceed to secondary school, whereas in 1999, there was a slight reduction to 74.60%. Currently, it is estimated that transition rates of Grade 7 pupils to secondary education are estimated at 78.15%, with males leading at 79.4% and girls lagging at 76.8% (Munjanganja & Machawira, 2015).

#### **2.5.4 Pupil Performance in National Examinations**

Botswana's emphasis on education, particularly on the primary education front, has paid meaningful dividends, not only in enrolment, completion and transition, but on the pass rate as well. Having inherited a poorly developed education system with only 20% of its children in school and just 8 % of those managing to progress to secondary education, it has managed to increase these figures to close to 100%. In terms of achievement in the Primary School Leaving Exam (PSLE), in the past eight years, more than 60% of the pupils have obtained Grade C or better in all their examinations. From an impressive performance of 72.9% PLSE pass rate in 2007, performance slumped to a low pass rate of 64 % in 2011, but has since been on a recovery path such that in 2014, the pass rate was recorded at 69.2%. More students have excelled in their local language than in any other subject. A majority have also fared well in Mathematics and English. Figure 6 below shows the trend in Setswana, Mathematics and English pass rates from 2007 to 2014. These pass rates are considerably higher than those in Zimbabwe and South Africa.

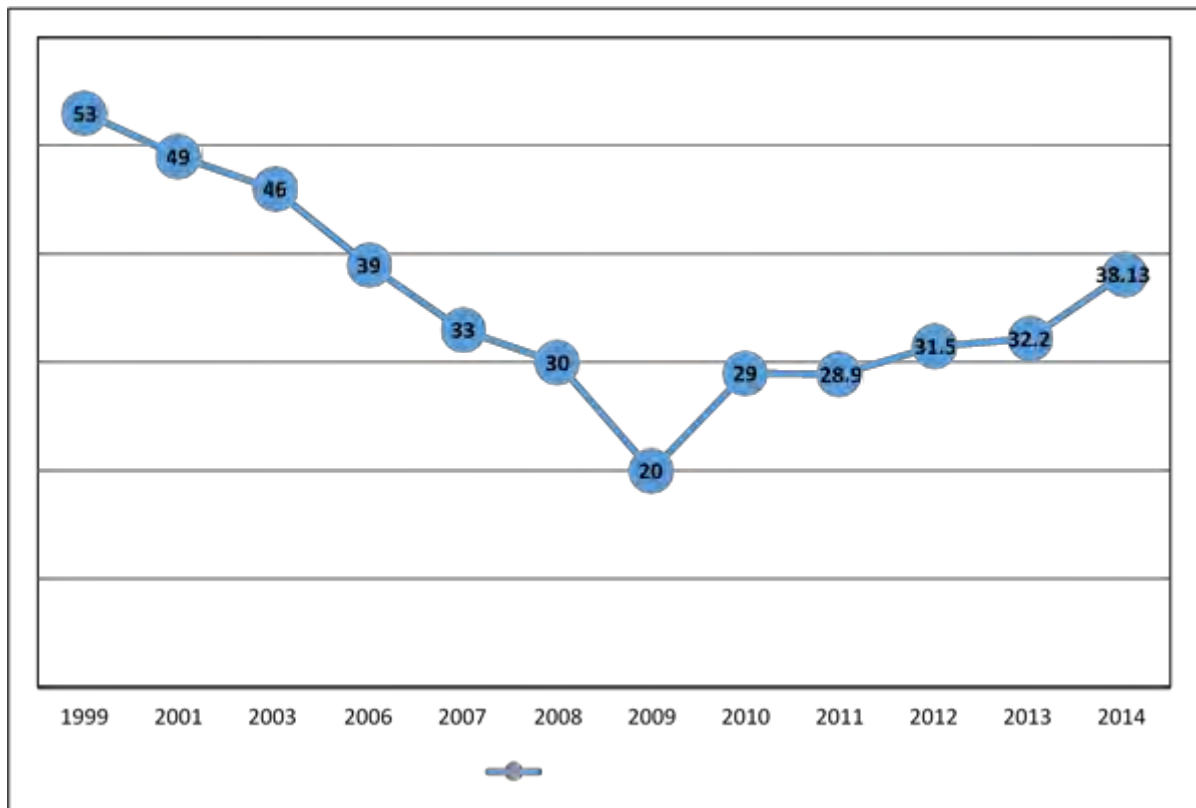


**Figure 5: Botswana's Primary School Leaving Examination Results, 2007-2014**

Source: Botswana Examinations Council (2011-5)

Unfortunately, in Zimbabwe, the success rates observed in enrolment figures, completion and transition rates have not been followed by impressive examination pass rates. Shiza (2013) shows that student achievement based on the Grade 7 primary leaving examinations in Zimbabwe has been on a downward trend for some time. Even though there has been improvement in recent years, the pass rates have remained significantly low. Figure 7 below shows that in 1999, the Grade 7 pass rate was 53%, and thereafter was in free fall during the economic and political crises period, resulting in a low pass rate of 20% in 2009. Thereafter, data shows that Grade 7 pass rates have slowly improved and as at 2014, the national pass rate

was estimated at 38.13 %. Such a low pass rates show that Zimbabwe is in dire need of establishing ways of improving student achievement.



**Figure 6: Zimbabwe Grade 7 Examination Results, 1999-2014**

Source: Shiza (2013)

National assessment results for Grade 6 pupils in South Africa are equally unimpressive. Though these are not the final primary school exams, the fact that they are nationally coordinated makes it easier to compare at the national level since the same tests are taken across all primary schools in the country. The final examinations however are not the same across schools nationwide and hence are difficult to draw meaningful comparisons from them. These results show that even though much has been achieved in all other indicators, a majority of the students are not performing above average in their final primary school examinations. Table 1 below presents a snapshot of student performance in Mathematics, Home Language



and First Language final examinations, for the period 2012-2014. Though their Home Language pass rates were at 38.7%, this has risen to 74.6% in a space of three years. Mathematics scores have improved, though not to impressive figures, as have the fluctuating First Language pass rates.

**Table 1: Grade 6 National Annual Assessments Results average scores (%)**

	<b>2012</b>	<b>2013</b>	<b>2014</b>
Mathematics	10.6	26.5	32.4
Home Language	38.7	67.6	74.6
First Additional Language	24.4	41.2	36.1

Source: South Africa Department of Basic Education (2014)

## **2.6 Chapter Conclusion**

Expansion of education, particularly basic education, has been a preoccupation and major concern of all the countries under study since the attainment of majority rule. Several strategies have been initiated, such as subsidies and the complete removal of school fees, as well as the construction of more schools and provision of extra teachers. Gender equality is also regarded as an important issue in terms of enrolment. Though this has not been effectively achieved, it shows that all three countries are cognisant of the need to ensure gender balance in access to basic education and the transition to secondary school.

In Zimbabwe, however, assessment outcomes, which act as proxies for indicators describing the knowledge and skills a child acquires from the education system (Zimbabwe National Statistics Agency, 2013) have shown a rather unpleasant situation. Student pass rates have been very low. In Botswana, although slightly more than two thirds of the children who sat for their Standard 7 exams pass, it is still a low figure considering that all children are important human capital for the benefit of the country at large and for themselves and their households as well. In South Africa and Zimbabwe, the results are far below average. This is worrying because student achievement signals a properly functioning process that produces people who are able to contribute meaningfully to their families' and country's social and economic well-being. Hence, investing heavily in the educational sector without bringing about the much desired results is a cause for concern and must be addressed without delay. It is therefore imperative for research such as this to be conducted in order to help ascertain which areas can be improved, thus enabling more children to succeed. This research, focusing on Grade 6 pupils, seeks to investigate the extent to which selected variables predict student mathematics achievement, which could assist in establishing how students can profit from their time in school.

## **Chapter Three**

### **Literature Review**

#### **3.0 Introduction**

The literature on the determinants of student achievement is now vast, in both developed and developing countries. Key contributions to this discourse can be drawn back to the seminal paper by Coleman et al, (1966), whose controversial findings that family background and community characteristics were more important in explaining student achievement differentials across schools than school resources and teacher characteristics, led to more researchers from across the disciplines to explore this issue, employing various methodologies and datasets. Without exhausting all such literature, this section zeroes in on that which is deemed critical in informing the research methodology and general approach of this paper. Prior to a review of the empirical literature, this section first discusses the educational production function as a theoretical foundation for studying the determinants of student achievement. A conclusion is then presented at the end of this review.

#### **3.1 The Education Production Function**

To better understand the research findings in empirical educational research, it is important for one to be familiar with the underlying conceptual models of the educational process (Hanushek, 1986). The principal framework employed in this field is the education production function framework. This approach, as with the conventional production function, has inputs (such as school resources, socio-economic characteristics, and teacher characteristics), and outputs (mainly student achievement) and the schools are equated to the conventional

factories. Hence, an education production function defines the structural relation between various inputs and outputs (achievements).

The education production function illustrates that there are several factors that influence a student's outcome, though the relationship is more complex in real-world settings than is presented above. The education function is nevertheless not without its shortcomings. It assumes that academic achievement is measured by test scores, whereas there are many other outcomes in a school setting besides test scores (Bowles, 1970). Although research in this area may differ in method of analysis, data source and type, the above serves as a guiding framework.

### **3.2 Empirical Literature on determinants of student achievement**

The seminal work of Coleman et al, (1966), which was based on the Equality of Educational Opportunity Survey (EEOS), initially sought to ascertain the extent of racial segregation in American schools. This nationally representative sample of elementary and secondary school students had comprehensive data on student test scores, their family backgrounds, their teachers' attributes, the schools they attended, and on the characteristics of their communities. This enabled Coleman et al, (1966) to estimate the effects of a selection of variables on students' academic achievements. Applying ordinary least squares (OLS) regression analysis, they observed that variations in family background and community-level characteristics better explained student achievement differentials across schools than variations in school resources (such as pupil/teacher ratios or expenditure per pupil), and teacher characteristics (such as experience and degree levels). The research further stated that to a lesser extent, peers also had an influence on variations in student performance. These findings later generated considerable debate and further research on factors influencing student achievement across

different disciplines, with some scholars concurring with the findings and others disputing them.

Bowles and Levin (1968) analysed the Coleman Report and observed that the EEOS data made it impossible to account for within regional differences, as in some instances data was aggregated at a district level and then averaged across the districts' schools. In a region with both black- and white-only schools for example, aggregating and averaging their school resources understated white-only school resources and in turn overstated the black-only school resources (Bowles & Levin, 1968). Also, only a limited number of school facilities were considered by Coleman et al, (1966), with no class size variable, which Bowles & Levin (1968) claim severely understated the effects of school-level variables on student outcomes. In terms of methodology, employing a simple linear regression was deemed inappropriate, as Bowles and Levin (1968) argued that it simplified the relationship between student achievement and several predictors of different platforms. Thus employing a competent statistical analysis was seen to at least salvage more substantive findings, despite data limitations.

Additionally, Bowles & Levin, 1968 stated that the failure by Coleman et al, (1966) to report regression coefficients and standard errors hindered the policymaker in comparing the relative effectiveness of different variables, which would have enabled them to ascertain which resources would be more effective in per dollar of expenditure (Bowles & Levin, 1968). Furthermore, Bowles and Levin (1968) criticised the assumption made by Coleman et al, (1966) that variables under study were not correlated. They argued that such an assumption underestimated the confounding effects of variables considered. Lastly, they argued that the peer influences observed by Coleman et al, (1966) were due to the fact that parents

consciously selected schools so that students of similar backgrounds and achievement levels attended the same school.

Despite the concerns raised by Bowles and Levin (1968), several subsequent studies which analysed the Equality of Educational Opportunity Survey (EEOS) data, reached the same conclusion as that of the Coleman Report (Armor, 1972; Jencks et al, 1972 in Kostantopoulos & Borman, 2011; and Gamoran & Long, 2006). They all concurred that family factors were important in predicting academic achievement, even after taking into account the critiques made against the Coleman Report on sampling procedures, information gathering techniques and analytical methods.

Summers and Wolfe (1977), upon analysing Philadelphia School District data which captured longitudinal information on students, teachers and school characteristics (from Grade 3 through Grade 6), found results that were contrary to those of the Coleman Report. They observed that many school inputs did matter and more specifically, certain inputs were critical in assisting disadvantaged children to succeed. Summers and Wolfe (1977) established that teachers who had degrees from higher-rated colleges were associated with high pupil grades, whilst children from lower income families benefited the most (a result obtained by interaction effects). Additionally, Summers and Wolfe (1977) showed that above average 3rd. graders' benefited more from experienced teachers, whereas low achievers benefited the most from less experienced teachers, probably because the newer teachers had an "undamped enthusiasm" for teaching the low performers. Black students and low achievers did well in smaller classes, whilst high achievers did better in larger classes (above 28 pupils) and average students were not significantly affected by class size.

Over the three-year period under study, Summers & Wolfe (1977) observed that boys grew almost one month less in achievement scores than their counterparts, thus concluding that girls

performed better than boys. The study revealed that a student's first grade IQ had a significant effect on student achievement growth, whilst an interaction of IQ and student race showed an additional significant positive effect of IQ on non-black students. Furthermore, interaction effects showed that higher-income students were negatively affected by more unexcused absences (a proxy for motivation), and low-income students in turn were adversely affected by being late. Summers and Wolfe (1977) established that the availability and condition of physical facilities did not make any significant difference in student achievement in the Philadelphia School District. Summers and Wolfe (1977) attributed such results to their ability to use a rich dataset that had extensive pupil-specific data, as suggested by Bowles and Levin (1968). When Summers and Wolfe (1977) tested their hypothesis using class averages, they found contrasting results which were similar to those obtained by Coleman et al, (1966) claiming no significant effects of schools on achievement, thereby validating the Bowles and Levin (1968) concerns of using aggregated data to estimate determinants of student achievement.

Motivated by the Coleman Report findings, policymakers in the United States began to prescribe policies that focused on supplying additional resources to families with low-achieving children, abandoning school-based compensatory programmes. Unfortunately at that time, Murnane, Maynard and Ohls (1981) observed that policymakers lacked knowledge concerning key resources in the home that influenced student achievement, thus affecting the effectiveness of their intervention strategies. Seeking to fill this knowledge gap, Murnane, Maynard, and Ohls (1981) studied the roles played by certain resources in the home in influencing children's achievements in low-income urban black families. They employed a linear model that included family demographic characteristics, school attributes and the students' prior achievement scores. Prior scores were considered necessary in this analysis as they enabled an estimation of the value addition of home resources. The study found no

relationship between physical resources or particular school programmes and student achievement. Instead, they observed that the abilities of adults who spent a substantial amount of time with children had a noticeable effect on the academic performance of students. Hence, they concluded that in order to improve student achievement, it was imperative that policymakers focus on improving human inputs (such as training teachers and educating parents so that they are aware of the importance of their children's education), rather than focus on material inputs.

Wendung and Cohen (1981) analysed public school data drawn from the Basic Educational Data System (BEDS) of the New York State's Education Department, with the intention of verifying the claims that school resources made no significant difference to student achievement. Similar to Murnane, Maynard, and Ohls (1981), they observed that greater teacher quality (measured by years of experience and educational status) was related to student achievement in Grade 3 and 6 students, in English and mathematics. Furthermore, they established, contrary to Coleman et al, (1966), that variations in spending and education resources and the socio-economic status of the school community made a difference in average achievement in New York public schools, though they concurred that peer effects had an effect on student achievement. Interestingly, they found that pupil/teacher ratio had a significant positive association with student achievement, a result confirming the results by Summers and Wolfe (1977) that significant positive effects on above average students in Philadelphia. The study also observed that their results tended to vary per subgroup, as factors that measured differences in achievement among metropolitan and suburban schools did not explain variations among rural schools to the same extent. Though the study analysed aggregated data like the Coleman Report, they arrived at contrasting conclusions.



Observing an influx of education production function literature at that time, Hanushek (1986) reviewed such literature, seeking to explore what had been learnt, with the aim of identifying gaps in the literature on the production and efficiency aspects of schools from as early as elementary school till secondary school. His review revealed that increasing expenditure on inputs and school quality was not followed by an increase in student achievement across all grades. In 1989, Hanushek did a further literature review, focusing on the impact of differential expenditures on school performance in the USA's public schools (both secondary and primary). This review focused on 187 papers in 38 books and journals. He came to the same conclusions that were reached in the 1986 review: that there was no strong significant relationship between school expenditure and student performance (Hanushek, 1989).

Heyneman and Loxley (1983) questioned the tendency of some scholars to assume that findings from one part of the world could be generalised to any other part of the world without undergoing some empirical testing. In particular, the researchers observed that debates on the significance of school resources in influencing educational outcomes were mainly active in developed countries and that there was a tendency of some scholars and other stakeholders to assume that such results were universally applicable elsewhere, even to less developed nations. They argued that the failure of schools to make a significant difference in the USA should not be generalised to other parts of the world without any empirical testing (Heyneman & Loxley, 1983).

Consequently, Heyneman and Loxley (1983), employing OLS, examined the Second International Mathematics and Science Study (SIMSS), a dataset that covered both developed and developing countries, in order to assess the effects of school resources on student achievement in primary schools. Contrary to the Coleman Report conclusions, school characteristics were observed to be more important than family socio-economic status in

determining student achievement, and a higher effect was observed in developing countries. Students' socio-economic status was found to have a weak impact on their academic achievements; it was rather the quality of schools and teachers to which children were exposed that affected their achievements. Thus, Heyneman and Loxley (1983) concluded that at least in developing countries, school contexts were more important than external factors in enhancing student achievement. Their analysis became one of the most prominent studies of cross-national comparisons of the determinants of student achievement. Also, these findings captured considerable attention in school effectiveness research and became popularly known as the Heyneman-Loxley Effect.

Hedges, Laine and Greenwald (1994) reanalysed the papers reviewed by Hanushek (1989); their reanalysis showed systematic positive patterns in the relations between educational resource inputs and student outcomes. Hedges, Laine and Greenwald (1994) concluded that money did matter in schools and that it was not possible to ignore the importance of more resources on student achievement. However, they stated that there still needed to be an efficient allocation of these resources amongst the schools concerned.

A meta-analytic study by Greenwald, Hedges & Laine (1996) on several production function researches revealed that school resources had a positive influence on student outcomes. Variables such as pupil expenditure and teacher remuneration were observed to have a significant positive and consistent influence on student achievement. Also, having small schools, low student-teacher ratios, and good teacher quality was seen to positively impact on student outcomes. However, Hanushek (1997) maintained that there was neither a significant nor consistent relationship between school resources and student educational outcomes, at least after variations in family inputs were taken into account. Hanushek (1997) employed meta-analytic approaches as used by Greenwald, Hedges & Laine (1996), reviewing 400

examples of educational production literature. He argued that the sampling method employed by Greenwald, Hedges & Laine (1996) was biased towards retaining both statistically significant positive results and insignificant but positive results – just the direction that led to supporting their general conclusions. Therefore, Hanushek (1997) argued that simple resource policies held little hope for improving student outcomes.

In Zimbabwe, Nyagura and Riddell (1993) employed a 3-level multilevel modelling technique to investigate the causes of primary school achievement variance between different primary school categories in mathematics and English language. In the analysis, the primary schools were placed into five categories: high fee-paying (private); former group A; former group B; low fee-paying; and rural district primary schools. These categories were instituted by the settler regime such that private high fee-paying/trust schools were schools which catered for the more affluent segment of the white population whereas former group A government schools were those that previously catered for the European (white, Asian and coloured) population; and former group B government schools previously catered for the urban African (black) population. Low fee paying schools were mostly non-government urban schools catering for the black urban population; and rural district community schools catered for the economically and socially disadvantaged rural and farming African (black) segment of the population, constituting about 70 percent of the national population (Nyagura and Riddell, 1993:25). Using the official Ministry of Education's final leaving examinations (Grade 7), the paper found that for both subjects group A and high fee-paying schools performed better than the rest, followed by group B and low fee-paying schools, and at the bottom, district council schools. Primary school student achievement was seen to be influenced by the amount of teacher training, the pupil-teacher ratio for both subjects and instructional time, particularly for mathematics, and that these issues were prevalent in the rural areas.

Baker, Goesling and LeTendre (2002) sought to establish whether the Heyneman-Loxley effect was still valid, considering that there had been significant increases in enrolment and provision of school resources. Using OLS and a 2-level HLM to examine data from the Third International Mathematics and Science Study (TIMSS) of the 1990s, they observed that the Heyneman-Loxley effect had subsided. In the HLM, their cross-level interactions between GDP/Capita and family background or school resource predictors were insignificant. Hence, family background and school resources were found not to vary significantly across countries with different levels of economic development (Baker, Goesling and LeTendre, 2002). They observed that in all countries under study, irrespective of their economic status, family background variables were much more significant predictors of student achievement, relative to school resource variables. These results were seen to persist even after controlling for the quality of school resources and a country's level of economic development (Baker, Goesling and LeTendre, 2002). The research concluded that what determined student outcomes after such significant developments were factors external to the school. However, they did not completely rule out the Heyneman-Loxley effect, as they conceded that it could be valid in those countries still rooted in deep poverty, with epidemics and unrest, which made it impossible to introduce mass school enrolment programmes.

Similarly, Ilie and Lietz (2010) sought to find evidence of the H-L effect and analysed data for 21 European countries that participated in the Trends in International Mathematics and Science Study (TIMSS) in 2003. The study used a Hierarchical Linear Model (HLM) technique in place of the traditional OLS estimator used by Heyneman and Loxley (1983) and Baker, Goesling and LeTendre (2002), and also accounted for interactions between their selected variables. GDP was found to have no direct effect on student mathematics performance, once other factors were taken into account. Ilie and Lietz (2010) observed that the school-level variables were no more likely to have significant effects on achievement in

low-income countries than they were in high-income countries, and that the variables did not account for the variance in achievement in these countries. At the same time, two of the three student context variables – books in the home and parental education – consistently related to achievement across 19 of the 21 countries, regardless of those countries' levels of economic development. Ilie and Lietz (2010) concluded that the context in which students are raised is very critical to their academic performance relative to the school environment.

Though the HL-effect argued that the relevance of school quality decreased for higher-income countries as the effect of family-level variables became stronger, 3-level HLM regressions performed by Ilie and Lietz (2010) supported this claim only in the case of the number of books in the home. Their results suggested that the likelihood of students who came from homes with more books performed at a higher level in mathematics became more pronounced as a country's GDP rose. In contrast, the negative interaction effect of GDP with the language of instruction not being spoken at home suggests the likelihood that students who speak the language of instruction at home will perform at a higher level than their peers, is less pronounced in higher-income countries (Ilie & Lietz, 2010). No interactions emerged for GDP and its relationship with student absenteeism, school mathematics resources, school climate, and student achievement (Ilie & Lietz, 2010). The only exception was the percentage of students still enrolled at the end of the academic year, where the interaction indicated that student performance in schools with varying dropout rates was greater in less economically developed countries. In conclusion, Ilie and Lietz (2010) stated that there was little evidence to support the Heyneman-Loxley effect in the selected group of countries in 2003, and they maintained that home environment was an important factor in student achievement in all countries, irrespective of the level of economic development.

Howie (2003) explored factors relating to South African pupils' performance in mathematics and English language on the TIMSS 1999 survey, using partial least squares and multilevel analysis. The multilevel analysis showed that 55% of the variance in the mathematics achievement scores was situated at the school level, whilst 45% of the variance was at the student level. The research observed a strong positive effect of proficiency in the language of instruction (English/Afrikaans) and mathematics performance. In addition, variables such as socio-economic status, learner self-concept (about having difficulty with mathematics) and the importance of mathematics (according to mother, friends and the learner) were also significantly related to mathematics achievement. Lastly, Howie (2003) observed an influence of school location (rural/urban), and the teacher's attitudes, beliefs and dedication on mathematics achievement.

Zuze (2010) explored the link between teaching inputs and pupil mathematics performance in the Botswana state-run education system using TIMMS and SACMEQ II data. A 2-level multilevel analysis of the SACMEQ II (primary school) and TIMMS (junior secondary school) data revealed a significant positive relationship between student socio-economic status and mathematics achievement in both surveys, with a stronger association observed on the SACMEQ II data. Grade repetition was linked to lower performance in primary schools. Students who had repeated a grade at least once scored nearly 50 points lower compared to their peers who had never repeated a grade. Where student achievement was lower for repeaters, there appeared to be positive effects related to repetition at the school level. At the junior secondary level there was a strong positive association between measures of student self-efficacy and their actual mathematics performance.

At the school level, the research established a positive significant relationship between average social background of a school and mathematics performance in both primary and

junior secondary schools. Resource-rich schools were found to have an advantage. Schools with teachers who had a better grasp of their subject matter performed better. This effect was over and above their professional training and educational levels because these variables were also included in the final model, although they did not have separate significant effects. According to the TIMMS data, students benefited from being taught by teachers who had a tertiary qualification, even though a tertiary qualification is not a requirement to train as a junior secondary school teacher in Botswana. Teachers with a degree were found to more likely teach at senior secondary level.

A study by Lee and Zuze (2011) investigating the links between student achievement and several resource inputs in Uganda, Namibia, Malawi and Botswana using SACMEQ II data, also found similar results to those of Zuze (2010). Employing a 2-level multilevel model, the study found strong links between material and human resources and Grade 6 student achievement in reading and mathematics. The research also found that structural features such as school size and having shifts negatively affected achievement to various extents across the countries.

Kostantopoulos and Borman (2011) reanalysed the Coleman et al, (1966) data using a more sophisticated methodology than that employed by Coleman et al, (1966). The 2-level multilevel model that they used to assess the effects of school characteristics net of the family background effects was mainly aimed at ascertaining whether using more sophisticated statistical methods would change the results obtained by Coleman et al (1966). To gauge the effects of schools on student achievement, they employed both the regression and multilevel models. They found significant between-school variances in student achievement, suggesting school effects. Also, school characteristics used in the model explained a substantial proportion of the between-school variation in achievement. Hence, schools were seen to play

a meaningful role in distributing equality / inequality of educational outcomes to females, minorities and the disadvantaged.

Visser, Juan and Feza (2015) conducted a multiple regression analysis on the 2011 Trends in International Mathematics and Science Study (TIMSS) data to determine the resources factors that influence South African student performance in mathematics, focusing on Grade 9 students. The findings reveal that both school and home environments play significant roles in student mathematics performance. Having more assets had the highest positive effect on mathematics performance such that having an additional asset enabled a learner to score on average eight points higher in mathematics. Using the language most frequently spoken at home in the test enabled a student to score 32 points higher than those who used a language less spoken/never spoken at home. Having a parent with qualifications higher than Grade 12 enabled the student to perform on average 16 points higher than learners with parents who had lower qualifications. Students in schools that needed minor repairs or had no need of repairs performed at least 21 points higher than those in more dilapidated schools. Parents, who were more involved with their children's homework and their being enrolled in a large class, had a negative effect on student performance.

Winnaar, Frempong and Blignaut (2015) employed a 2-level multilevel analysis to establish school effects in South Africa on the basis of the 2011 TIMMS data. Focusing particularly on Grade 9 pupils, the research established that differences in schools in South Africa accounted for 62% of the variance in student achievement in mathematics. The research found that students who were enrolled at well-resourced schools performed better than those from less resourced schools. Also, students taught by satisfied teachers, as well as those trained to teach mathematics did better than those with less motivated teachers and those who were not trained to teach maths. At the student level, it was found that students who were almost always bullied



performed significantly lower than those who were less often or never bullied, and those who were of the appropriate Grade 9 age performed better than overaged children. At the student level, children who reported to be less motivated and those who almost always got assistance from their parents did less well than students who were interested in the subject and those whose parents were less involved.

### **3.3 Chapter Conclusion**

The discussion in this chapter has shown that ever since the controversial findings of the Coleman Report a vast amount of literature has been published, albeit with contrasting results. There has been a never-ending debate on whether environmental factors have a large effect on student achievement, or rather whether it was student and family level factors that had a more significant effect on student achievement. As the years have passed, researchers drifted away from the American data. This led to the introduction of educational production function research in developing countries, and the introduction of cross-country comparisons between and within developed and developing countries.

Additionally, as educational achievement research became popular overtime, more sophisticated methodology and research design has been introduced. The OLS estimation technique has come under intense scrutiny. Better methodologies started to proliferate in the 80s, and multilevel models started dominating in many papers. The argument for the adoption of such models was due to the nature of education data, which is nested or clustered in nature. Educational data was seen to violate a critical assumption of OLS, that of observational independence. That is, individuals clustered within one group are likely to be more similar to other members of that group than to individuals clustered within another group. This resulted in the estimation of less efficient parameter estimates, according to Raudenbush and Bryk (1988).

Surprisingly, the change in data, country contexts, methodologies and time frames has not brought an end to the debate on what better explains student achievement. Rather, all these innovations have added more to the contrasting evidence. This review shows that there is still a need to ascertain what better explains student achievement, especially in developing countries where there has been limited research in this area. Additionally, though a few recent researchers in developing countries has employed Hierarchical Linear Modelling/Linear Mixed Models, the author observes that there has been a concentration of papers applying 2-level multilevel models, when in actual fact most schools in developing countries exhibit more than two levels of hierarchies. The data analysed in this research shows that in the countries under study, most schools have more than one Grade 6 class. This means that they have different teachers and resources for all Grade 6 classes. Such a situation then implies that it is incorrect to assume that all classes in a school are of the same environment. Thus, this research argues that there is a need to add one more level to account for between-class differences within a school, rather than aggregating school-level and class-level variables.

In a nutshell, the reviewed literature shows no conclusive evidence on which variables better explain student achievement the world over. In addition, the strength and direction of the relationships between factors and performance has appeared to be inconsistent across studies. It has also shown that it is not possible to assume that results obtained in one country apply in another country without empirically establishing so. Lastly, it is observed that most studies that have employed multilevel models have limited their analysis to 2-level models when in fact 3-level models may be ideal. Such findings show the importance of continuing research in the area, employing improved methodologies, different measures of variables and country contexts. To fill this gap, the following chapter will outline a methodology to assess the effects of various variables on student achievement, motivated by the reviewed literature above.

## **Chapter Four**

### **Data and Methodology**

#### **4.0 Introduction**

This section describes the data and methodology employed in this study. It unfolds by discussing the data, its composition and sources, and how it was collected. Motivated by the reviewed literature, we then discuss the variables of interest and methodology used in the research. Lastly the underlying assumptions are stated.

#### **4.1 Data**

In analysing the determinants of student achievement, this study utilises nationally representative sample survey data collected by the Southern African Consortium for Monitoring Educational Quality (SACMEQ). Specifically, SACMEQ's third round data (SACMEQ III) is utilised. SACMEQ is a developmental organisation made up of 15 Southern and Eastern African member states working in collaboration with the International Institute of Education Planning (IIEP). Founded in 1995, its main mission is to carry out training and research activities amongst its member states for monitoring and evaluation of the general conditions of their education systems to enable effective education policymaking (Hungu et al, 2010).

Since its inception, SACMEQ has successfully completed three large-scale cross-national studies on the conditions of schooling and the quality of education in its member states. The SACMEQ I project (1995-1999) included the collection of information gathered from about 20 000 learners, 3 000 teachers and 1 000 school principals. The Project II (2000-2004) data collection covered approximately 40 000 learners, 4 000 teachers, and 2000 school principals.

The SACMEQ III Project (2006-2011) involved data collection from around 60 000 learners, 8 000 teachers, and 2 800 school principals (Makuwa, 2010). Currently it is finalising its 4th project, which commenced in 2012. As stated by Lee and Zuze (2011), longitudinal data would be more precise for comparability purposes, but because of the unavailability of such data in the countries under review, this study relies on cross-sectional data. The study will be descriptive and hence limited to ascertaining the associations between an array of variables and student achievements.

## **4.2 Study Population and Sample**

The SACMEQ III target population was made up of level-6 pupils, their respective teachers and their school heads at registered mainstream educational institutions in the 15 countries, in the year 2007. To select a sample from the population, a stratified two-stage cluster sample design was used. Firstly, schools were selected in each region/province proportional to the number of pupils in that region in the defined target population. At the second stage, a simple random sampling approach was employed to select 25 students within each identified school. The project excluded Grade 6 enrolments of fewer than 20 students (Makopa, 2011). To avoid selection bias, the teachers and head teachers did not take part in the sample selection process (Hungu, 2011). Allowing teachers and school heads to select students for this type of study could give them an opportunity to forward their best students and hence distort the outcomes of the project.

Having identified the sample from the population, achievement tests were administered to the sample of students and their teachers. The tests covered mathematics, reading, and HIV/AIDS knowledge. In addition to the tests, three sets of questionnaires were administered to the sample. One set was given to the sample of Grade 6 pupils, soliciting information about their individual and family backgrounds. The second questionnaire was given to the relevant

teachers to solicit information on their personal backgrounds, their class composition and characteristics, their experience and qualifications. The last questionnaire which solicited information regarding school-wide factors such as staffing levels, school enrolment, available resources and the overall school condition was completed by school heads. The number of students, teachers and school heads for each country for the SACMEQ III study are presented in Table 2 below.

**Table 2: Number of students, teachers and schools in SACMEQ III sample**

Country	Schools	Teachers	Students
Botswana	160	385	3868
South Africa	392	1163	9071
Zimbabwe	155	274	3021

Source: Hungi (2011)

### **4.3 Description of Variables**

Guided by previous student achievement studies and the availability of data, this study recognised three level-factors that relate to student learning in formal schools. These are student-level, classroom-level and school-level factors. Previous multilevel studies recognised two levels: the student-level and the school-level. However, within a given school, there are two levels that have different effects on student achievement. Within a school, the education process of instruction and learning takes place in the classroom and the school provides the conditions necessary for instruction at the class-level, hence it is important to recognise these distinct levels in student achievement research (Creemers & Reezigt, 1996). This section provides a description of the variables included in this analysis.

A summary is presented as an epilogue to this section. Some of the variables were taken without modification from the SACMEQ III dataset, whereas others were restructured to suit the intentions of this research. This section is critical as it spells out which variables were used, and how some of them were modified.

#### **4.3.1 Dependent Variable**

The dependent variable used in this analysis was the student standardised mathematics score. SACMEQ administered a mathematics examination to the sample of students, which tested their numeric, spatial and measurement ability. Student scores were standardised to a SACMEQ mean of 500 and a standard deviation of 100.

#### **4.3.2 Proposed factors at the student, classroom and school levels.**

- **Student-Level Covariates**

At the student-level, the research considered five variables. The first variable considered was student gender. This is a dummy variable which estimates the effect of gender differences on student maths achievement. Being female was coded 1, and otherwise, 0. Like most variables in student achievement research, the gender variable produced mixed results in various researches. Girls were generally found to outperform boys in primary school in both maths and reading (Summers & Wolfe, 1997; Tremblay, Ross & Berthelot, 2001; Voyer & Voyer, 2014). Lee and Zuze (2011) however, found that in some countries, boys actually did better than girls.

Also at the student-level, a variable capturing a student's repetition history was considered. The variable Repetition is a dummy variable where those that have ever repeated a grade are assigned the value of 1, whereas those who have never repeated are assigned the value of 0. A student who is repeating a grade can be expected to do fairly well considering that he/she

is revising familiar material (Lee, Zuze & Ross, 2005). But this becomes less obvious for instance if the student is repeating because he/she has had less time at school possibly due to an illness. In a case where a student is not academically able, repeating might not improve a student's score. It might make the child worse off as he/she might be demotivated, leading to poor performance, dropouts and behavioural problems (Westbury, 1994; Gomes-Neto & Hanushek, 1994; Hungi, 2010). Hence, repetition does not necessarily translate to improved achievement.

Hungi (2010) reveals that on average 37.1% of students in countries that participated in the SACMEQ III project had repeated at least once. In Botswana and Zimbabwe, roughly 31% of students in the sample had repeated a grade, whereas 29% was the approximate figure for South African students. Other SACMEQ countries, namely Malawi, Mozambique, Swaziland, Uganda and Lesotho have recorded repetition rates above 50%, based on the sampled students (Hungi, 2010). With such high repetition rates, this research would assume that most students repeat because of poor academic ability, which leads to no significant positive gains in achievement.

The provision of extra lessons in addition to the conventional school hours has become a worldwide phenomenon with different motives. Paviot (2010) states that in some countries extra lessons are usually taken as a remedial strategy for students with learning difficulties, whereas in other countries they serve as enhancement strategies aimed at students who are already coping but aim at meeting certain benchmarks. There is a high incidence of students enrolled for extra lessons in SACMEQ countries; on average, 15.5% of pupils engage in private lessons. In Zimbabwe, it is estimated that 15.4% of primary school students engage in extra lessons, whereas in Botswana and South Africa the percentages are 5.9% and 4%, respectively (Paviot, 2010). Thus, to enable us to estimate the effects of extra lessons on

student achievement, a variable, extra lessons, was included in the analysis to show whether or not a pupil supplemented his/her conventional maths classes with private lessons. This is a dichotomous variable, coded 1 if the pupil enrolled in extra lessons and 0 if not. Unlike repetition, extra lessons enable a student to proceed with their peers; this might reduce elements of demotivation and eventual dropout.

An individual who is conversant with the language of instruction would be expected to be more comfortable in understanding maths concepts compared to one who has difficulties in speaking and understanding it. The student who has these difficulties can be expected to have problems grasping the key concepts and even correctly responding to test questions. To estimate the probable effects, a dummy variable, ‘speaks instructional language’ was included in this analysis. Students, who always or occasionally speak the language of instruction at home, were assigned the value of 1 and those who never do so were assigned the value of 0.

In addition, the research assessed the effects of a students’ socio-economic status (SES) on achievement at the student-level. Children coming from households with a high SES have been found to significantly do better in school than those who come from poorer households (Coleman et al, 1966; Tremblay, Ross & Berthelot, 2001; Lee & Zuze, 2011). Students hailing from low SES households are thought to come from poor home academic environments such that they are not motivated to excel. Generally, the high SES families have parents who might have attained a reasonably high level of education such that they act as reference points and motivators for children. Additionally there is a possibility that high SES parents have high cognitive ability. Thus, if this is inherent in the children, they too are most likely to succeed in school. To estimate the effect of SES on student achievement, a proxy variable constructed by SACMEQ to capture the economic and social well-being of a student’s family was used.



The proxy was created using questionnaire responses which related to the availability of certain items in students' homes.

In constructing the SES variable, SACMEQ used the Rasch Model, with the aid of the ConQuest software program (Dolata, 2005). A Rasch model converts numerous responses made by pupils into one composite score, which is then taken as a proxy for the family's social and economic well-being. The process involves individual ordering to indicate increased levels of a response on some variable such as the father's education level, or having a dummy for the availability of a certain item such as a telephone. The highest score in this case would be 1, the lowest being 0. These are then summed up to give each pupil a score, and the higher the score, the better off a pupil is relative to the others.

The process of constructing a measure of SES of the pupils involves identifying items linked to the index, coding the selected items, creating a data matrix as required by ConQuest, selecting the appropriate items and finally, constructing the measurement scale (Dolata, 2005). Elements selected by SACMEQ were those that defined the pupils' family environment: parental levels of education; number of books in the home; structural quality of the house (floor, roof and walls); source of lighting; and the presence of 11 items in the pupils' homes. These were running water; a car; a telephone; a refrigerator; a television set; a VCR; a radio; magazines; a newspaper; an audio cassette player; and a table (Dolata, 2005). It is argued that such proxies for household income are ideal because they exhibit the buying power of a household and are stable over time. The SES scores were then centred at 500 and scaled to have a standard deviation of 100. The lowest score became 212 and a maximum score of 802 was observed. Based on these results, students were then separated into three categories: those that fall into the top quarter, middle half and bottom quarter. The top quarter families

are the wealthier ones, and the bottom quarter families are regarded in the sample as relatively poor.

- **Classroom-Level Covariates**

At the classroom-level, a dummy variable was created to capture the effects of having the relevant textbooks in a given classroom. The variable Textbook was created in that those who had individual copies and those who shared were coded 1, whereas those who did not have textbooks and those who studied in a class with only a teacher's copy were assigned the value of 0. *Ceteris paribus*, students who had access to textbooks would be expected to do well in tests (Nyagura & Riddell, 1993). One of the reasons for doing well could be that the student had an opportunity to revisit maths concepts and revise during study time. Such practices would then improve student achievement. However, it becomes complicated when children have access to the textbooks but do not utilise them as expected. Some studies have found no impact of textbook availability on student achievement (Kuecken & Valfort, 2013).

Another dummy variable included in the study was Teacher qualifications. This variable showed whether or not a teacher had received teacher training in the subject in question. Teachers who received any teacher training were coded 1, and those without training were coded 0. Having suitably trained teachers is a key ingredient to student success. If teachers are not familiar with what they are to teach, they are not likely to impart the expected information. This then hinders student success. Thus, one would expect teacher qualification to improve student achievement.

The final variable included at the classroom-level was class size. This is the total number of Grade 6 students in a class as recorded in a class attendance register. Class size effects on student achievement have featured prominently in educational achievement literature, albeit with mixed results. The research included this variable at the classroom-level to assess its

effects on student mathematics achievement. Intuitively, having small classes would be expected to enable students to maximise their contact time with the teacher. Also, poor performers are expected to benefit more from such contact time when classes are smaller (Summers & Wolfe, 1977). However, past research has produced mixed results pertaining to the effects of class size on student achievement (Case & Deaton, 1999; Badr, Morrissey & Appleton, 2003; Lee, Zuze & Ross, 2005; Lee & Zuze, 2011). Being able to understand the effects of class size on student achievement is highly relevant to policy, as it informs how much investment in both human and material resources is required to reduce class size and help improve achievement.

- **School-Level Covariates**

We sorted schools into two categories, those privately administered and those linked to the government. The dummy variable, Private school, was used for this categorisation, where dummy code 1 stands for schools that are privately run, and 0 for public institutions. School ownership and control affect school operation. Thus, in some cases, researchers have found that students who learn in private schools tend to perform better than those from public institutions, whilst others have found exactly the opposite. Some papers have also found no significant effects of school ownership on achievement. Such mixed results make it important to consider such a variable, as it might be place-specific in that simply implying what one research has uncovered in a different context might not achieve much.

In an effort to estimate the influence of a school's wealth status on student achievement, a variable named School resource was included in the analysis. The School resource variable was a standardised composite measure of the school's physical resources/infrastructure. The variable was computed by SACMEQ based on the school head's response to some resource indicators, with a maximum of 22. Resources that made up this score included the availability

of a school library; school hall; staff room; playground; school garden; perimeter fence/hedge; computers; projectors; computer rooms; and a separate office for the headmaster. This variable helped compare schools in terms of their SES. Those schools with lower scores are considered as poorer than those who scored higher on this measure. The calculation of this variable was similar to that of calculating the students' SES score, discussed above. School resources have been argued to be important predictors of student achievement in past researches (Heyneman & Loxley, 1983; Lee & Zuze, 2011), though others argue that these are not important in student achievement (Coleman et al, 1966; Hanushek, 1997). A summary of the variables adopted for this analysis follows.

Table 3: A summary of proposed factors at the three levels

VARIABLE	DESCRIPTION
Mathematics Score	Standardised student's mathematics score for the test administered to the sample of students. It had a mean of 500 and a standard deviation of 100. [Outcome variable].
Female	This was a dummy variable with the value of 1 if the individual was female, or 0 if otherwise.
Repetition	Revealed whether or not a student had ever repeated a grade. It was a dummy variable for student grade repetition. It had a value of 1 for having repeated at least once, and 0 for not having repeated any grade.
Extra lessons	Indicated whether or not a student attended extra lessons. It was a dummy variable with the value of 1 if the student had a private tutor, 0 for not enrolling in extra lessons.
Speaks instructional language	Pupil speaks language of instruction at home. Dummy coded 1 for those who always speak or occasionally speak the language of instruction at home, and 0 was assigned to those who never speak it at home.
Socio-economic Status	Student's SES is a proxy for household relative wealth. A composite variable was made by converting numerous responses by students about the availability of certain items in the home. These were then individually ordered and then summed up to form one composite variable, centred at a mean of 500 and a standard deviation of 100. The SES score had two extremes, one with a low score of 212 for the relatively poorest household, and 802, highest score, representing the richest households in the sample. Further, the student scores were divided into three groups; a top quarter group, the middle half, and bottom quarter groups. Top quarter households were relatively the richest and bottom quarter households were relatively the poorest.
Textbook	Student access to mathematics textbooks. Those students with individual copies or who share with their peers were assigned the value of 1 and those without were assigned the value of 0.
Class size	Total number of Grade 6 pupils in a class. A continuous variable for Grade 6 class size.
Teacher qualifications	Dummy for teacher professional qualification. Coded 1 if teacher has received any training and 0 if teacher never received any training.
Private school	This was a variable that tested the effects of school ownership on student achievement. It was a dummy variable where a private institution was coded 1, or 0 if government run.
School Resources	Standardised school resource level is a proxy for school wealth. It is a composite of various items found in a school such as toilets, library, sports grounds and offices. The higher the score the wealthier the school. The SACMEQ data shows that the minimum score is 158.75, and maximum score is 831.41.

#### **4.4 Multilevel Modelling**

This research adopted a multilevel/linear mixed-effects model to estimate the determinants of student achievement in the selected countries. This method of analysis was appropriate considering the type of data being analysed, which was nested/clustered in nature. Previous researchers such as Bryk and Raudenbush (1988), Nyagura and Riddell (1993), and Ker (2014), applied it to similar researches. Traditional analyses such as the Ordinary Least Squares (OLS) have been deemed inappropriate in this type of research as they tend to ignore the dependence in the data which emanates from the grouping of observations. As such, analysing the data at the group level was observed in order to inhibit straight forward inferences or predictions at individual level (Ker, 2014).

Additionally, a fundamental assumption of most statistical models is that observations included in the analysis are uncorrelated or ‘independent’ of one another (Putnam-Hornstein, 2013). Hierarchical data violates this assumption as individuals clustered within one group are likely to be more similar to other members of that group than to individuals clustered within another group. It was therefore, assumed that these structures led to less efficient parameter estimates and also inhibits the analysis of critical interrelationships between the different levels (Nyagura & Riddell, 1993). This dependence is prevalent in institutions like schools because of the shared experiences among students and the non-random assignment of students to schools, which is usually based on location (Kreft & Leeuw, 2002).

Bryk & Raudenbush (1988) and Ker (2014) also stated that such an analysis by traditional regression models at single-level leads to biased estimates of standard errors and draws different conclusions even in carefully controlled experiments. Moreover, “the inherent nesting of educational systems in which students are nested in classes which, in turn, are nested in schools, which, themselves, are nested in districts or regions, makes the covariance

within each level of direct interest” (Nyagura & Riddell, 1993: 11). Therefore, as noted by Bryk and Raudenbush (1988), multilevel modelling tries to address this problem by incorporating the unique effects of individual schools into the statistical model for the outcome, thus the estimates adjust for the intra-class correlation which emanates from cluster sampling. Such analyses help explain student achievement as a function of student-level, school-level or classroom-level characteristics, while taking into account the variance of student outcomes within schools, and modelling between and within-school variance at the same time (Webster et al, 1996).

Another problem with traditional analyses is that in this kind of setting one has to assume that educational interventions have a constant effect on all students who are exposed to them, and these effects are invariant across organisational contexts (Bryk & Raudenbush, 1988). However, this greatly undermines the individual and contextual differences that are present within educational systems to the extent that a “one-size fits all” policy might not be effective in all areas. Thus, to get more efficient estimates and not undermine the dependence that exists within such data structures, multilevel models are more appropriate. They too enabled us to establish the source and extent of variance between the recognised levels.

#### **4.5 Multilevel Model Specification**

This section is devoted to the development of the model tailored for this research. The model specifications were influenced by theory and past empirical research. This subsection thus specifies the models employed in seeking to estimate the determinants of student achievement, detailing the basic notation and later formulate the model using response and predictor variables. Lastly, the assumptions underlying the models are stated.

#### 4.5.1 The variance components model

In analysing data using multilevel models, one has first to run a variance components model (also known as a null/empty model). This model is initially run for three main reasons: firstly, it decomposes the total variance; secondly, it helps the researcher estimate the intra-class correlation coefficients; and lastly, it acts as a baseline to measure the extent of variation explained by the model (Tremblay, Ross & Berthelot, 2001). Having a baseline model makes it possible for a researcher to estimate explained and unexplained variances in comparison to conditional models (Kreft & Leeuw, 2002). Decomposing the total variance is done by running a model which has an outcome variable (in this case the student mathematics achievement score), a fixed intercept term, and random effects associated with all levels recognised by the researcher. Breaking the variance into its micro-components assists us to ascertain the extent of variation due to students, classrooms and schools (Raudenbush & Bryk, 2002). In a three-level null model, there are three corresponding sub-models, each representing a different level. The first model (student-level) presents a student's academic achievement as a function of a classroom mean, plus a random error, and is presented as:

$$Y_{ijk} = \pi_{0jk} + \varepsilon_{ijk} \dots\dots\dots (1)$$

Where

$Y_{ijk}$  Is student  $i$ 's achievement score in classroom  $j$  of school  $k$ ;

$\pi_{0jk}$ , is an intercept (mean achievement score) of classroom  $j$  of school  $k$ ; and

$\varepsilon_{ijk}$ , is a random (student) effect for student  $i$  in class  $j$  of a school  $k$  (Raudenbush & Bryk, 2002).



Building from equation (1) above, the level 1 intercept (classroom mean achievement score)  $\pi_{0jk}$  becomes the outcome in level 2 varying randomly around some school mean to form equation (2) below:

$$\pi_{0jk} = \beta_{00k} + r_{0jk} \dots \dots \dots (2)$$

Where

$\beta_{00k}$  Is the school level intercept (mean achievement in school  $k$ ); and

$r_{0jk}$  Is a random (classroom) effect of class  $j$  in school  $k$ . thus,  $r_{0jk}$  is the deviation of classroom  $jk$ 's mean from the school mean (Raudenbush & Bryk, 2002).

Finally, the 3<sup>rd</sup> level (school) model representing the variability among schools where we view the school means as varying randomly around a grand mean is presented as:

$$\beta_{00k} = \gamma_{000} + \mu_{00k} \dots \dots \dots (3)$$

Where

$\gamma_{000}$  Is the grand mean; and

$\mu_{00k}$  Is a random effect associated with school  $k$ . it is the deviation of school  $k$ 's mean from the grand mean.

Substituting equations (1)-(3) produces the following Linear Mixed Model;

$$Y_{ijk} = \gamma_{000} + \mu_{00k} + r_{0jk} + \varepsilon_{ijk} \dots \dots \dots (4)$$

The above composite equation (4) presents a student  $i$ 's mathematics achievement score ( $Y_{ijk}$ ) in class  $j$  of school  $k$  as a function of a grand mean ( $\gamma_{000}$ ), random effects for student  $i$  in class

$j$  of a school  $k$  / student effect ( $\varepsilon_{ijk}$ ), random effects of class  $j$  in school  $k$  class effect ( $r_{1jk}$ ), and random effects associated with school  $k$  ( $\mu_{00k}$ ).

As stated by Tremblay, Ross & Berthelot, (2001), by running the null model we are able to determine Intraclass Correlation Coefficients (ICC). These are important because they enable us to empirically justify employing a linear mixed-effects model in analysing our data in place of a simple linear regression (West *et al*, 2015; Occhipinti, 2012). In the context of a linear mixed-effects model with random intercepts, the ICC is a measure describing the similarity (or homogeneity) of observed responses within a given cluster (Kreft & Leeuw, 2002; West *et al*, 2015). The ICC ( $\rho$ ) indicates the proportion of the variance explained by the grouping structure in the population. It is therefore the proportion of group-level variance compared to the total variance. In the context of this research, West *et al* (2015) and Hox (2010) present the formulae below to calculate the ICC;

$$\rho_{School} = \frac{\delta_s^2}{\delta_s^2 + \delta_c^2 + \delta^2} \dots \dots \dots (5)$$

$$\rho_{class} = \frac{\delta_s^2 + \delta_c^2}{\delta_s^2 + \delta_c^2 + \delta^2} \dots \dots \dots (6)$$

Equation 1 above shows the proportion of the total random variation in the observed responses due to the variance of the random school effects. Equation 2 shows the proportion of the total random variation due to random between-school and between-classroom variation (West *et al*, 2015).

#### 4.5.2 Formulating the conditional/full model

After having established the extent of variability, the research proceeds to estimate a conditional or full model. This model is basically built on the foundations of the null model.

It is slightly more complicated relative to the null model because of the inclusion of covariates at the 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> level. The level one model with one student level covariate takes the form;

$$Y_{ijk} = \pi_{0jk} + \pi_{1jk}A_{1ijk} + \varepsilon_{ijk} \dots \dots \dots (7)$$

Equation (7) above presents a student  $i$ 's achievement score ( $Y_{ijk}$ ) in class  $j$  in school  $k$  as a function of a student level predictor ( $A_{1ijk}$ ) such as pupil gender or age. In the same equation,  $\pi_{0jk}$  is an intercept (mean score),  $\pi_{1jk}$  is the slope/coefficient for a predictor  $A_{1ijk}$ , and  $\varepsilon_{ijk}$  represents the random effect for student  $I$  in class  $j$  of a school  $k$  (student effect). Building from equation (7), the classroom-level models become;

$$\pi_{0jk} = \beta_{00k} + \beta_{01k}X_{1jk} + r_{0jk} \dots \dots \dots (8)$$

$$\pi_{1jk} = \beta_{10k} + \beta_{11k}X_{1jk} + r_{1jk} \dots \dots \dots (9)$$

In equations (8) and (9) above, the level 1 intercept  $\pi_{0jk}$  and level 1 slope  $\pi_{1jk}$  become the level 2 outcomes, whereas parameters  $\beta_{00k}$  and  $\beta_{10k}$  are level 2 intercepts. Coefficients  $\beta_{01k}$  and  $\beta_{11k}$  are level 2 slopes and the error terms  $r_{0jk}$  and  $r_{1jk}$  are random effects of class  $j$  in school  $k$  (class effect). In the same vain, the 3<sup>rd</sup> level model is formulated as follows;

$$\beta_{00k} = \gamma_{000} + \gamma_{001}W_{1k} + \mu_{00k} \dots \dots \dots (10)$$

$$\beta_{01k} = \gamma_{010} + \gamma_{011}W_{1k} + \mu_{01k} \dots \dots \dots (11)$$

$$\beta_{10k} = \gamma_{100} + \gamma_{101}W_{1k} + \mu_{10k} \dots \dots \dots (12)$$

$$\beta_{11k} = \gamma_{110} + \gamma_{111}W_{1k} + \mu_{11k} \dots \dots \dots (13)$$

Where level 2 slopes and intercepts become outcomes.  $W_{1k}$ , represent level 3 predictors, whereas  $\mu_{00k} \dots \mu_{11k}$  are random effects associated with school  $k$ .

Similar to the null model formulations, to obtain a linear mixed-effects model, the different level equations above are combined to form one composite equation. The process entails substituting level 3 equations into level 2 equations, which in turn are substituted into the level 1 equation. Essentially, equations (10), (11), (12) and (13) are substituted into equations (8) and (9). Relevant to the objectives of this research, the linear mixed-effects model is presented in equation (14) below;

$$\begin{aligned}
 Y_{ijk} = & \gamma_{000} + \gamma_{100}A_{1ijk} + \gamma_{010}X_{1jk} + \gamma_{001}W_{1k} + \gamma_{011}X_{1jk}W_{1k} + \gamma_{101}A_{1ijk}W_{1k} \\
 & + \gamma_{110}A_{1ijk}X_{1jk} + \gamma_{111}A_{1ijk}X_{1jk}W_{1k} + \mu_{00k} \\
 & + r_{0jk} + \varepsilon_{ijk} \dots \dots \dots (14)
 \end{aligned}$$

Parameter  $\gamma_{000}$  in the equation above is a constant, which is interpreted as the estimated mathematics achievement score for a particular student in a given class at a stipulated school, when all variables assume the value of zero. Parameters  $\gamma_{100}$ ,  $\gamma_{010}$  and  $\gamma_{001}$  are slopes/coefficients for student level, classroom and school level variables  $A_{1ijk}$ ,  $X_{1jk}$  and  $W_{1k}$  respectively.

Parameters  $\gamma_{011}$ ,  $\gamma_{101}$  and  $\gamma_{110}$  are cross-level interaction effects of the student, class and school level variables. In equation (14) above, the portion  $\gamma_{011}X_{1jk}W_{1k}$  shows a school level variable  $W_{1k}$  acting as a moderator on the relationship between the dependent variable and a student level predictor  $X_{1jk}$ . Interactions of variables from different levels are termed cross-level interactions (Hox, 2010). Interaction terms provide information on the differences over and above the main effect of the explanatory variable of interest. Some scholars have theorised the existence of interactions between certain variables of interest. For instance Hanushek *et al*

(2005) observes a positive correlation between student achievement and exposure to own-race teachers. This shows that teacher race moderates the effects of student race on their achievement. Ammermuller & Dolton (2006) observe a positive joint pupil-teacher gender interaction effects in maths achievement in England. Also, Mueller (2013) finds that class size effects are moderated by teacher effects. In small classes students do well when they have experienced teachers. Such interactions bring out interesting outcomes that otherwise would not have been achieved had only variables been considered in isolation. To select the interaction effects, the study will rely on previous literature as reviewed in the preceding chapter.

The segment containing  $\gamma_{000} + \gamma_{100}A_{1ijk} + \gamma_{010}X_{1jk} + \gamma_{001}W_{1k} + \gamma_{011}X_{1jk}W_{1k} + \gamma_{101}A_{1ijk}W_{1k} + \gamma_{110}A_{1ijk}X_{1jk} + \gamma_{111}A_{1ijk}X_{1jk}W_{1k}$  is known as the fixed/deterministic part of the model and contains fixed coefficients. In the above equation (14), we also have symbols,  $\varepsilon_{ijk}$ ,  $r_{0jk}$  and  $\mu_{00k}$ , which are known as residual terms at school, class and student level, respectively. The segment that contains these residual terms  $\mu_{00k} + r_{0jk} + \varepsilon_{ijk}$  in equation (14) is called the random/stochastic part of the model.

The above illustration considered a situation where there were only one variable per level for ease of explanation, however, this research considers several variables per each level. Specifically, there are 5 variables at the student level, 3 variables at the classroom level and 2 variables at the student level which are considered in this research, the choice of which were motivated by theory, empirical literature, as well as the availability of such variables in the SACMEQ III dataset. Some variables that had a theoretical and empirical appeal could not be considered because of the extent of missing observations in the data which if we had considered them would greatly undermine the validity of the research.

Additionally, the research explores cross-level interaction effects. When we have many variables in three-level multilevel modelling, we have an enormous number of possible two-way and three-way interactions. Including these cross-level interactions further complicate the multilevel model, especially when more than one variable is considered at each level. Though in principle these interactions are possible, the equations are complicated and can be difficult to estimate and follow from a conceptual point of view, (Hox, 2010). For simplicity, this empirical analysis only focuses on cross-level interactions for these variables; female, class size, school type and repetition. The choice of variables was are influenced by past research as well as data availability. Hence using appropriate value labels, the reduced form equation (14) above can then be written as:

$$\begin{aligned}
 \text{Math Score} = & \gamma_0 + \gamma_1 \text{Female} + \gamma_2 \text{Repetition} + \gamma_3 \text{Extra lessons} \\
 & + \gamma_4 \text{Speaks instructional language} + \gamma_5 \text{SES} + \gamma_6 \text{Textbook} \\
 & + \gamma_7 \text{Teacher Qualification} + \gamma_8 \text{Class Size} + \gamma_9 \text{Private School} \\
 & + \gamma_{10} \text{School Resource} + \gamma_{11} \text{Female} * \text{Class Size} + \gamma_{12} \text{Repetition} \\
 & * \text{Class Size} + \gamma_{13} \text{Female} * \text{Class Size} * \text{School Type} + \mu_{00k} + r_{0jk} \\
 & + \varepsilon_{ijk} \dots \dots \dots (15)
 \end{aligned}$$

Where  $\gamma_1, \gamma_2 \dots \gamma_5$  is the slope for level-1, level-2 and level 3 variables, whereas  $\varepsilon_{ijk}$ ,  $r_{0jk}$  and  $\mu_{00k}$  are random errors for levels 1, 2 and 3 respectively.

#### 4.4.1 Assumptions of the Model

This model had critical assumptions underlying it and these are outlined below, according to Subedi (2004):

- a) The error terms of each level have a mean of zero, and are multivariate normally distributed.
- b) There is a linear relationship between predictors and outcome variables at all levels.

- c) Another assumption is the assumption of homoscedasticity, thus all variables have equal variances.
- d) Level-1 predictors are independent of the level-1 error term, Level-2 predictors are independent of all level-2 error terms and level-3 predictors are independent of all level-3 error terms.
- e) The level-1 error terms are independent of (uncorrelated to) level-2, and level-3 error terms in the model.

Since the above assumptions are very strong, this paper is descriptive and does not assume causality amongst the dependent and the independent variables.

## **Chapter Five**

### **Empirical Results**

#### **5.0 Introduction**

This chapter presents the estimates of the linear mixed-effects model and the interpretation of the results. The first section presents a preliminary analysis that shows how the countries under study perform in SACMEQ III maths tests. These scores are decomposed into different strata. A discussion on simple statistics, the matrix and how missing data was handled follows thereafter. The null model results are then discussed followed by the full model results. Later, the random-effect variances, post-estimation Intraclass correlation coefficients (ICC) and the likelihood-ratio test results are presented and discussed.

#### **5.1 Preliminary Analysis**

- **Student mathematics performance in SACMEQ III**

An analysis of the SACMEQ III data shows that in terms of mathematics performance, Botswana has a relatively higher mean achievement of 520.5, followed by Zimbabwe with 519.7. Lastly, South Africa with 494.5, as presented in Table 4. The South African students on average performed lower than the SACMEQ III mean of 509.7 (Hungu et al, 2010). Table 4 also presents inter-country comparisons in three other categories: gender, school location and socio-economic status (SES). It shows that Zimbabwean boys on average performed better, followed by Botswanan boys and lastly South African boys. In relation to girls, we observed that girls from Botswana came out top, followed by Zimbabweans and lastly, those from South Africa. In these three countries, it can be seen that on average in Zimbabwe boys



performed slightly better than girls by only 1.8 points. In Botswana and South Africa, compared to boys, girls did quite well.

**Table 4: Comparison of mean student mathematics performance in SACMEQ III study**

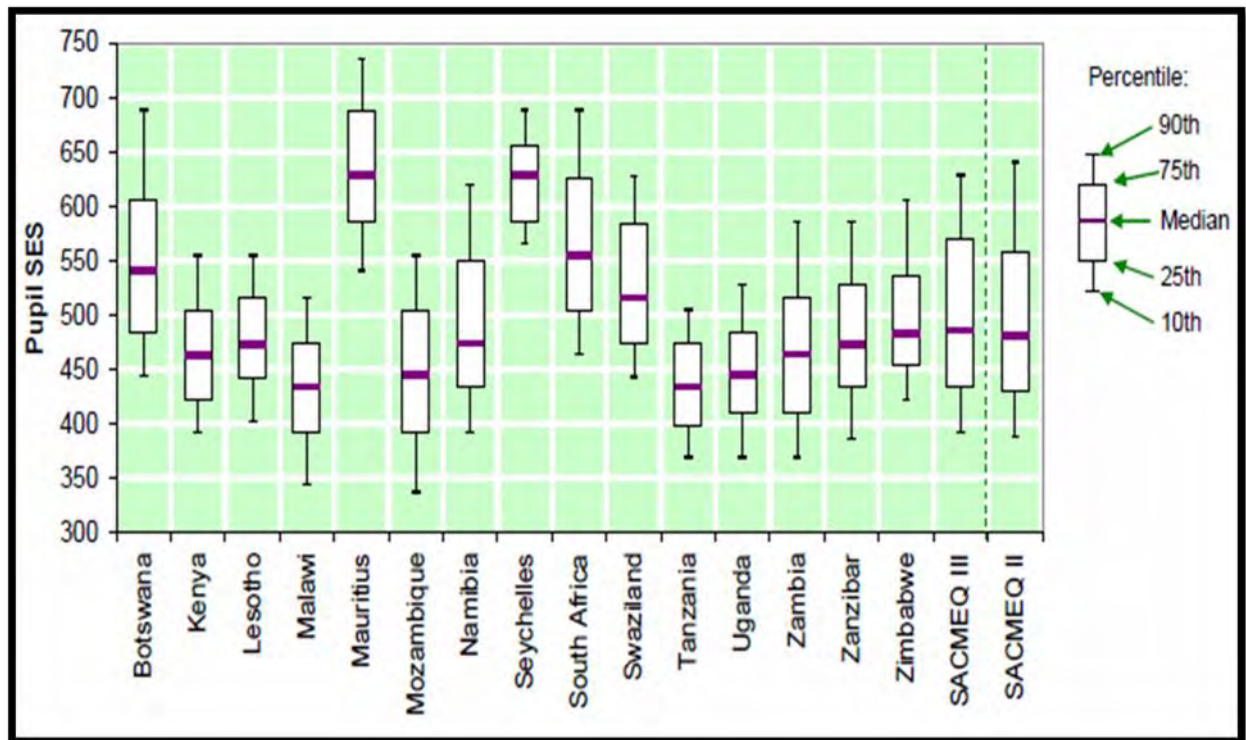
	Pupil Maths Performance		
	Botswana	South Africa	Zimbabwe
Sub-Group	Mean	Mean	Mean
<b>Pupil Gender:</b>			
Boys	517.5	491	520.8
Girls	523.6	498	519
<b>School Location:</b>			
Rural	501.1	457	492.1
Urban	538.8	533	589.6
<b>Socio-economic Status:</b>			
Low SES (Bottom 25 %)	479.0	446	487.8
High SES (Top 25 %)	553.1	579	588.8

Source: Hungi et al (2010)

Table 4 above also shows that in the context of the rural-urban achievement gaps in the three countries, students from urban areas do quite well relative to those in rural areas. Actually, the trend is the same across all SACMEQ countries; hence the mean achievement for all countries is 493.9 for students learning at rural institutions and 533.2 for those learning in schools located in urban areas (see Appendix I for a comprehensive table). Decomposing

student achievement by SES showed that those that came from families who fell into the bottom 25 % achieved relatively lower marks on average relative to those who came from the top 25 %. Additionally, in all countries, students who came from high SES households performed better on average than the country mean achievement, whereas in the case of low SES students, their mean achievement was below that of their respective country.

SACMEQ III results also confirmed that Botswana and South Africa are highly unequal countries in terms of wealth distribution relative to Zimbabwe and other SACMEQ countries. The boxplot below (Figure 8) shows the distribution of student socio-economic status in all SACMEQ countries. It shows that in Botswana and South Africa, students found around the 90th percentile score almost 700 on pupil SES score whereas the lower 10th percentile hovers around 450 points. Such wide margins indicate wealth inequality. On the other hand, Mauritius and the Seychelles have the highest student SES levels, and their lower 10th percentiles are above the average SES for almost all pupils in the SACMEQ countries. In Zimbabwe, the margin between the 90th and 10th percentile is modestly low relative to the other two countries under study.



**Figure 7: Distribution of student socio-economic status in SACMEQ countries**

Source: Hungu et al (2010)

- **Summary Statistics**

Descriptive statistics for the selected variables are summarised in their respective hierarchical levels in Table 5 below. Comparing mean mathematics achievement samples across the countries showed that Botswana students scored an average of 521.50, Zimbabwean students followed at 517.19 and South African students scored 496.89 points. The South African students performed below the SACMEQ mean of 500. Overall, there were more female students in the Zimbabwean sample (56%) and the South African sample (51%). However, the Botswanan sample had an approximately equal number of both males and females.

**Table 5: Summary Statistics of selected variables**

Variable	Botswana		South Africa		Zimbabwe	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
<b>Mathematics score</b>	<b>521.5</b>	<b>80.15</b>	<b>496.89</b>	<b>98.68</b>	<b>517.19</b>	<b>97.36</b>
<b>Student-Level Covariates</b>						
Female	0.5	0.5	0.51	0.5	0.56	0.5
Repetition	0.31	0.46	0.29	0.46	0.31	0.46
Extra lessons	0.24	0.42	0.1	0.3	0.23	0.42
Speaks instructional language	0.79	0.4	0.76	0.43	0.66	0.48
Socio-economic Status	2.02	0.7	1.98	0.71	1.9	0.73
<b>Class-Level Covariates</b>						
Textbook	0.95	0.21	0.74	0.44	0.77	0.42
Class size	29.42	4.89	41.61	12.47	38.35	10.34
Teacher qualification	0.68	0.47	0.99	0.1	0.69	0.46
<b>School-Level Covariates</b>						
Private school	0.09	0.29	0.05	0.21	0.69	0.46
School Resource	578.4	74.32	581.11	110.16	461.59	90.75

**Note:** Std. Dev. = Standard Deviation.

Based on the socio-economic variable summary statistics, it was observed that in all three countries, on average most students come from families who are in the middle-half category. Though the average is low for a Zimbabwean family, a higher average was observed in Botswana. Hence, Botswanan children on average are from wealthier families compared to the other two countries, whereas Zimbabwean students hail from relatively poorer ones. This conforms to each country's economic strength, as South Africa and Botswana are generally wealthier than Zimbabwe. However, knowing that South Africa is one of the most unequal countries in the world, it is important to take into account such in-country dynamics as that the wealth is heavily skewed towards the poor majority. According to the sampled students, information on student repetition shows that this is a common trend in these developing countries. Approximately 30 % of students in the sample had repeated at least a grade.

The class size statistics showed that an average class in South Africa has approximately 41.61 students, which is higher than the Zimbabwean (38.35) and Botswanan (29.42) average class sizes. Similar to the family wealth status, school resource averages were higher in Botswana, followed by South Africa, and lastly, Zimbabwe. These scores to an extent echo the situation on the ground across the countries under study. As an example, the Zimbabwean figures showed signs of an ailing economy that has compromised the provision of educational resources.

- **Correlation of Variables**

A correlation matrix was generated to check whether there was multicollinearity amongst the variables adopted for this analysis. According to Tabachnik & Fidell (2007), if the correlation coefficients exceed 0.90, it indicates multicollinearity amongst variables, and remedial measures should be taken to correct this so that the assumptions underlying the model may hold. The correlation matrix of the variables in use is presented in appendix II. The

correlation coefficient's sign shows the direction of correlation amongst variables. The correlation matrices below show that there is no coefficient that is anywhere closer to Tabachnik & Fidell's (2007) suggested benchmark. Based on these guidelines, it is safe to conclude that the data does not exhibit any collinearity between the variables used in this analysis, and can be included in the multilevel analysis.

## **5.2 Missing Data**

Missing data poses a threat to the accuracy and the reliability of regression estimates. Missing data can result from several reasons such as failure of the enumerators to accurately collate the gathered information, or possibly that the respondents willingly omit answering certain questions for reasons probably best known to themselves. Ignoring such an important issue greatly hampers the reliability of the research results. Fortunately, there are several ways that have been devised to cater for such scenarios, which are not rare in this kind of research. Knowing the pattern and extent of missing data will influence which remedial measure one can take to ensure that the results are more accurate in estimating the required phenomena. Thus, before a regression analysis was performed, the researcher examined the data to assess the severity and pattern of the missing data so that appropriate remedial measures could be employed. Below is a Table that shows the extent of the missing data in the sample.

**Table 6: Percentage of missing values per variable**

VARIABLE	PERCENTAGE MISSING		
	Botswana	South Africa	Zimbabwe
Mathematics Score	0.08	0.22	0.1
Female	0	0	0
Repetition	0	0	0
Extra lessons	0	0	0
Speaks instructional language	0	0	0
Socio-economic Status	0	0	0
Textbook	0	0	0.26
Class size	0	0	0
Teacher qualifications	0	1.49	0.83
Private school	0	0	0.93
School Resource	0	0	0
<b>Sample size</b>	<b>3868</b>	<b>9071</b>	<b>3021</b>

Table 6 above reports the percentage of missing data from the country-level samples. The missing data ranged from 0.08% for Botswana's mathematics achievement to South African teacher's academic qualifications. Seeing that the percentage of missing data is not huge, and based on the rule of thumb of 5% suggested by previous researchers such as Tabachnik and Fidell (2007) and Mohammadpour (2012), listwise deletion was used to handle the missing data. This missing data handling strategy had the consequence of reducing the sample size, with the assumption that exclusion of the missing information was so negligible that the results

obtained without them would be approximately similar to a regression where these were actually available.

### 5.3 Results from the unconditional/variance components model

The variance components model was run and the results are summarised in Table 7 below, for all the countries under study. Such a model enabled us to decompose the total variance into its student, classroom and school-level components. The constants (intercepts) presented in Table 7 are the overall mean student performance of all schools in the respective country samples. The highest mean student performance was observed for Botswana, estimated at 521.26, followed by Zimbabwe at 519.06 and lastly, South Africa at 496.29. These mean scores are similar to those observed in the preceding subsection on summary statistics.

**Table 7: Random-effect parameters of the null model**

Random-effect  Parameters	Botswana		South Africa		Zimbabwe	
	Coef.	S.E	Coef.	S.E	Coef.	S.E
Constant	521.26*	3.53	496.29*	3.76	519.06*	5.12
School-level variance ( $\delta^2$ )	1711.25	224.84	5259.20	395.84	3096.54	458.46
Class-level variance ( $\delta^2$ )	215.62	65.01	160.39	47.50	1015.93	225.32
Individual-level variance ( $\delta^2$ )	4489.43	107.99	4303.23	67.54	5490.75	150.29
Total Variance	6416.30		9722.82		9603.22	

Note: Coef. =Coefficient; S.E=Standard Error

\* Significant at the 5%,  $p < 0.05$  level



Table 7 above shows that in Botswana, there is a greater variance between students in the same classroom (4489.43), followed by a school-level variance (1711.25) and a relatively lower classroom-level variance of 215.62. Similar results were observed in Zimbabwe, albeit with differing margins. The South African variance partitioning gave different results altogether. South Africa's school-level variance was 54% of the total variance, and individual level variance accounted for 44 % of the total variance, with the remaining 2% being covered at the classroom-level. Howie (2003) obtained similar proportions in South Africa using TIMMS data, where 55% of variance explained was at the school-level and 45% explained at the student-level. Also, such high variances at the school-level in South Africa were observed by Cho (2010), who stated that 59% of variance was observed at the school-level and 41% at student-level, when analysing TIMSS 2003 English language data. Such large between- school variations indicate equity problems within South Africa's education system. Considering the historic past of South Africa, these sample results are not surprising, as such high variances at the school-level indicate academic inequality. The apartheid government's policies cascaded even to education provision at the primary level, to the point that students had different school systems based on their race. These results show that this inequality has not yet been effectively redressed.

As stated in the preceding chapter, the decomposed variances enable a researcher to calculate the intra-class correlation coefficients at different levels. Table 8 below presents the respective school and class-level ICCs. The ICC results show a relatively higher class-level ICC compared to the school-level ICC. This is to be expected, since students within classrooms are more likely to be similar than the students within a school (Siddiqui et al, 1996). Comparing the ICCs across countries, South Africa has a relatively higher school- level ICC (0.54) compared to Zimbabwe (0.32) and Botswana (0.27). Such high school-level ICCs signal that the student mathematics achievement in the same school is relatively homogenous, and that the scores

across schools vary widely (West et al, 2015). Correspondingly, a relatively high class-level ICC is reported in South Africa compared to other countries. This also signals a very low variation in the responses of students within the same classroom, compared to total random variation.

**Table 8: Intraclass correlation coefficients**

	Botswana		South Africa		Zimbabwe	
	Coef.	S.E	Coef.	S.E	Coef.	S.E
<b>Intraclass correlation</b>						
School	0.27	0.03	0.54	0.19	0.32	0.035
Class   School	0.30	0.03	0.56	0.02	0.43	0.029
Number of Students	3865		9051		3018	

**Note:** Coef. =Coefficient; S.E=Standard Error

Though the South African ICCs were observed to be the highest among the three countries, those of the other two countries were significantly high as well, and they exhibited the presence of homogeneity. Since they were significantly non-zero, the assumption of independent observation in the traditional linear model was violated, justifying the use of multilevel modelling for this kind of data (Kreft & Leeuw, 2002). In justifying the use of multilevel modelling as opposed to the traditional OLS, Occhipinti (2012) states that a widely used rule of thumb is that if there is a 10% total variance to be represented at any given level, then mixed models can be employed as a method of analysis. Thus, based on this rule of thumb, a multilevel technique was justified.

## **5.4 Conditional / Full Model Results**

The next stage consisted of analysing a conditional/full model. This model accommodated several covariates at all three levels as well as 2-way and 3-way cross-level interaction effects. The results are presented in Table 9 below. The discussion that follows is systematically arranged such that the first subsection pertains to student-level results, followed by the classroom-level and the school-level. Finally, the discussion ends with interaction effects results.

Table 9: Estimates of the effects of student, class and school covariates on student mathematics achievement

	Botswana		South Africa		Zimbabwe	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Constant	384.12**	25.43	351.78**	16.61	324.59**	23.16
<b>Student-Level Covariates</b>						
Female	27.58**	12.76	5.41	4.93	25.25**	11.80
Speaks instructional language	25.02**	2.85	16.37**	1.88	25.99**	3.48
Repetition	-28.42**	14.20	-23.11**	5.72	-21.04	12.83
Extra lessons	3.53	2.96	-13.59**	3.16	7.76**	3.86
Socio-economic Status :						
Middle Half	17.29**	2.91	7.59**	1.92	5.47	3.40
Top Quarter	41.81**	3.78	33.52**	2.72	36.57**	5.53

**Class-Level Covariates**

Textbook	40.37**	5.90	-0.18	2.37	9.68**	4.10
Teacher qualification	-0.42	3.36	-7.60	17.19	-2.21	6.12

Class size	0.30	0.53	-0.47**	0.21	1.15	0.62
<b>School-Level Covariates</b>						
Private school	82.18	45.57	-9.05	39.39	-9.29	29.25
School Resource	0.09**	0.03	0.33**	0.02	0.28**	0.04
Female*Class Size	-0.96**	0.43	-0.12	0.11	-0.64**	0.30
Repetition* Class Size	-0.12	0.48	-0.05	0.13	-0.34	0.33
Female*Class Size* School Type						
Male*Private	-0.63	1.51	0.31	0.99	0.39	0.73
Female*Private	-0.62	1.50	0.44	0.98	0.32	0.73
Number of Students	3865		8917		2958	

**Note:** S.E=Standard Error.

#### **5.4.1 The effects of Student-level Covariates on student mathematics performance**

At the student-level, we estimated the effects of student gender, grade repetition, extra lessons, and frequency of speaking the language of instruction, and family socio-economic status on mathematics achievement. The results showed considerable gender differences in mathematics achievement in Botswana and Zimbabwe. In Zimbabwe, a female student was predicted to score 25.25 points higher than a male student, whereas in Botswana the female students were estimated to score 27.58 points higher than their male counterparts. However, the study found no statistically significant gender differences in South Africa. Significant gender differences were also observed by Lee and Zuze (2011), as their study concluded that primary school girls in Botswana and Namibia performed better than boys, whereas in Malawi and Uganda they observed that boys did significantly better than girls. Summers and Wolfe (1977) also found similar results in Philadelphia, where, across three years (from Grade 3 through Grade 6) they observed that in performance, boys grew by almost a month less than girls.

The frequency of speaking the language of instruction at home was observed to be a key determinant of student achievement in all the countries under study. The results showed that frequently speaking in the instructional language at home enabled a student to score approximately 26 points higher in Zimbabwe, 25.02 points higher in Botswana, and 16.37 points higher in South Africa than those who never or less frequently spoke it. This result was very critical as it highlighted the need for students to be well-versed in the language of instruction. Failure to do so greatly disadvantages the student as he/she will not be able to grasp key concepts, let alone understand the requirements of a question in an examination. In a study on the role of language proficiency on student achievement in Namibia, using SACMEQ I data, Garrouste (2011) observed similar results, affirming the need for students

to be well-versed in the language of instruction. Smith (2011) also recognised the negative effects of lower fluency in languages of instruction in South Africa.

Student grade repetition is not uncommon in the Southern African education systems. Students repeat for several reasons; chief amongst these is failure to meet the examiner's pass marks at a given grade. One can thus take this as a proxy for the student's cognitive ability. This study found that those who had a history of repeating had poorer results relative to those who had never repeated, *ceteris paribus*. In Botswana, a student who repeated at least once was likely to score 28.42 points lower, while in South Africa, a student with a history of repeating was estimated to score 23.11 points lower than one who had never repeated a grade. However, the study found no significant effect of student grade repetition on student mathematics achievement in Zimbabwe. Assuming, therefore, that this was a signal of cognitive ability, these results were in line with the conventional wisdom, as those who were less able to cope with the school curriculum performed lower than those who were academically able. Previous studies, such as the Lee and Zuze (2011) study, observed a similar effect in Botswana when they analysed the SACMEQ II data, though their estimated effect was double of what this paper observed for the same country.

Instead of making students repeat grades, some parents, upon realising that their children were not performing as expected, resorted to enrolling their children for extra lessons with private tutors. This was believed to act as a supplement to the conventional lessons they received at school. The hope was that they would catch up with the other students in their class through these remedial lessons. This paper though, found mixed results when estimating the effects of extra lessons on student mathematics achievement. The results showed a positive significant effect of enrolling in extra lessons in Zimbabwe (7.76), and no statistically significant effect of taking up extra mathematics lessons in Botswana, whereas in South Africa, those

who enrolled for extra lessons were estimated to score 13.59 points lower than those who only attended conventional mathematics lessons.

With reference to the Zimbabwean results, if those that opted for extra lessons were students who struggled in class, the results could imply that extra lessons were effective in improving the student achievement of poor performers. However, it could also have been that some of the good performers were aiming at making their results even better. This then made it impossible to ascertain the overall effect of extra lessons on poor performers. At first glance the South African results could have been counterintuitive, but assuming that there had been self-selection such that poor performers were the ones who opted for extra lessons, these results showed that poor performers still performed lower than those who never repeated. However, this analysis was limited in terms of ascertaining whether this assumption holds.

The family socio-economic status variable showed that coming from a wealthy family significantly influenced student mathematics achievement in all the countries under consideration. The analysis revealed that Botswana students from families in the top quarter category of socio-economic status were estimated to achieve as much as 41.81 points higher than those in the bottom quarter bracket. Similarly high significant coefficients were observed in South Africa (33.52) and Zimbabwe (36.57). Those who fell into the middle half in terms of wealth status were estimated to score 17.29 points higher than students from the bottom quarter in Botswana, and 7.59 points higher in South Africa. However, the data revealed that there were no significant differences between the middle-half and bottom- quarter students in terms of achievement in Zimbabwe. Similar results were obtained by previous studies such as Coleman et al, (1966), and Lee and Zuze (2011), who found a strong effect of students' socio-economic background on their academic achievement.



#### **5.4.2 The effects of class-level covariates on student mathematics performance**

The availability of appropriate textbooks is considered critical in student learning. Their necessity is supported by results obtained in Botswana and Zimbabwe, where access to a mathematics text book had a significant positive effect on student achievement. In South Africa, the results showed no evidence on the effects of mathematics textbook access on student mathematics achievement. Specifically, having access to a textbook in Botswana was estimated to enable a student to score at least 40.37 points higher than one without access, where the score was estimated to be 9.68 points for a similar student in Zimbabwe, *ceteris paribus*. Possibly the non-significance of the textbook variable in South Africa could highlight issues of non-use of textbooks by students, which renders them irrelevant. Textbook availability is only effective if pupils are able to read and understand the language of instruction. In situations where students are not able to read or speak the language of instruction, having loads of textbooks does not add any value to student achievement.

Also, at the classroom-level, the research estimated the effects of teacher quality on student maths achievement. The results showed no evidence of the effects of teacher training on student achievement, at least for the countries under study. The non-significance of the teacher quality variable was observed by Coleman et al, (1966), and Hanushek (1986; 1989; 1997), who observed that factors outside the school were significant in explaining student achievement.

Class size effects on student achievement has featured prominently in educational achievement literature, albeit with mixed results (Badr, Morrissey & Appleton, 2003). This research found a statistically significant negative coefficient for class size in South Africa (-0.47 points). This implies an inverse relationship between class size and student performance. Thus students in smaller classes were predicted to attain higher marks relative to those in

larger classes. To the contrary, in Zimbabwe and Botswana, class size did not significantly influence student mathematics performance. Summers and Wolfe (1977) stated that small classes were beneficial to poor performers, whereas above average students do better in large classes compared to poor performers. The South African results confirm past observations by Case and Deaton (1999), who stated that a low pupil-teacher ratio was really beneficial to low performers, particularly to previously disadvantaged individuals. The Zimbabwe and Botswana results confirm previous findings by Lee and Zuze (2011), who also observed that in Botswana, class size had no significant effects on student achievement.

#### **5.4.3 The effects of school-level covariates on student mathematics performance**

At the overall school-level, resource endowment was predicted to significantly positively influence student mathematics achievement in all countries under study. The effects of a school's material resources were strongest in South Africa (0.33 points), followed by Zimbabwe with 0.28 points, and lastly Botswana with 0.09 points. Thus in all countries under study, school material resources were found to significantly positively influence student achievement. Such results imply that in South Africa, students who learn at relatively well resourced schools were predicted to score approximately 0.33 points higher than their counterparts who are enrolled at poorly resourced schools. In Zimbabwe and Botswana, the school resource advantage was predicted to be 0.28 points and 0.09 points respectively. These results were consistent with the previous literature, which observed a significant effect of school material resources on student achievement in developing countries, particularly on disadvantaged children (Wendung & Cohen, 1981; Heyneman & Loxley, 1983; and Lee & Zuze, 2011). School type was found not to significantly predict student maths achievement in all countries under study. The study found no significant effects of school type on student mathematics achievement in Zimbabwe and South Africa.

#### 5.4.4 Cross-level Interaction effects

This research considered three cross-level interaction effects. The two 2-way cross-level interactions considered were those between gender and class size, and between student repetition and class size. This research considered three cross-level interaction effects. The two 2-way cross-level interactions considered were those between gender and class size, and between student repetition and class size. The third interaction effect estimated was a 3-way cross-level interaction of gender, class size and school type. Even though the female students were seen to perform better than their counterparts, *ceteris paribus*, the interaction between gender and class size revealed rather different results in Zimbabwe and Botswana. It showed that female students performed about a point lower than male students in well-resourced institutions (- 0.64, and -0.96, respectively).

However, there was no evidence that suggested that the gender-class size interaction variable predicted student achievement in South Africa. The Zimbabwean results also showed that female students in well-resourced institutions were likely to score -9.22 points lower than their male counterparts, *ceteris paribus*. The repetition-class size interaction effect showed no significant effect on achievement in all countries under study. Therefore, taking class size into account, repeating students were seen not to significantly differ in performance compared to non-repeaters. This result was contrary to the negative effect observed on the repetition variable without a mediator. Specific to South Africa, where it was observed that an increase in class size negatively affected student achievement, an interaction with repetition did not yield any significant effects. The 3-level cross-level interaction effect had no interesting results, as the interaction effects were insignificant. Thus, we found that school type, combined with class size; have no significant mediating effects on student gender on student maths achievement.

#### **5.4.5 Analysing generic and country-specific factors influencing student achievement**

Apart from establishing which variables explained maths achievement at individual country-level, this research also sought to compare these results across the three countries. The results showed that there are some variables that were generic in terms of their influence on student achievement across all countries. The results showed that there are some variables that were generic in terms of their influence on student achievement across all countries. However, there are some that significantly predicted achievement in one or only two of the countries under study. The results also showed that there are some variables that were not significant at all in explaining student achievement. This subsection thus discusses the similarities and differences observed across countries in terms of factors influencing student maths achievement. Table 10 below gives a summary of this discussion.

**Table 10: Summary of results based on significance**

	Botswana	South Africa	Zimbabwe
<b>Generic factors influencing achievement</b>			
Speaks instructional language	+	+	+
School Resource	+	+	+
Socio-economic Status – Top-Quarter	+	+	+
<b>Country-specific factors influencing achievement</b>			
Female	+	0	+
Socio-economic Status– Middle-Half	+	+	0
Textbook	+	0	+
Repetition	-	-	0
Extra lessons	0	-	+
Class size	0	-	0
Female*Class Size	-	0	-
<b>Factors Insignificant in all Countries</b>			
Private School	0	0	0
Teacher qualification	0	0	0
Repetition* Class Size	0	0	0
Female*Class Size*School Type:			
Male*Private	0	0	0
Female*Private	0	0	0
<b>Note:</b> +/- significant variables 0 insignificant variables			

- **Generic factors influencing student achievement**

In the three countries under study, some factors were found to be generic. Firstly, at the student-level, student gender significantly positively influenced student achievement. It was observed that female students did better than male ones in the study. Students who frequently spoke the language of instruction at home were predicted to score higher marks than those who did so less often, or never at all, in the three countries. Finally, at the student-level, it was established that those who came from the top-quarter families in terms of socio- economic status, attained far better marks relative to those who came from families identified as being of the bottom-quarter socio-economic status. Thus in all countries, students coming from wealthier families were predicted to achieve higher grades, and those hailing from poor families were expected to score lower marks. At the school-level, in all countries under study, being able to study at a better resourced school relative to a less resourced one, predicted better maths scores.

- **Country-specific factors influencing achievement**

Some variables were observed to predict student achievement in only two or only one of the three countries under study. Results showed that qualified teachers in Zimbabwe only predicted student achievement, whereas students at private institutions were estimated to perform better than those in public schools, only in Botswana. The effects of mathematics textbook availability on student achievement in the same subject were observed in Botswana and Zimbabwe, but no conclusive evidence of such effects was observed in South Africa. Regarding students' socio-economic status on achievement, those hailing from families regarded as being of the middle-half status were predicted to score better than those hailing from poorer bottom-quarter families in Botswana and South Africa. Similarly, it was only in Botswana and South Africa where student grade repetition was observed to significantly

negatively affect student maths achievement, whereas in Zimbabwe, no significant effects were observed.

Contrasting results were obtained in the estimation of the effects of extra lessons on student math achievement between Zimbabwe and South African students. The study revealed that large classes as well as attending extra lessons significantly negatively influenced student achievement in South Africa, whereas in Zimbabwe, class size had no significant effect and extra lessons significantly positively influenced achievement. Results also showed that teacher qualification did not significantly influence student mathematics achievement in any of the three countries under study. With regard to interaction effects, the study estimated that in terms of gender and class size, females did worse than boys in large classes in Botswana and Zimbabwe. The other two interaction effects were not significant in all the countries under study.

Overall, the research found that student-level predictors had higher significant coefficients, which led to the conclusion that at least for all the countries under study, student-level factors better explain their mathematics achievement scores. These large coefficients at the student-level would tempt one to conclude that student-level factors are more important in explaining achievement. However, this does not mean that other factors should be negated.

### **5.5 Proportion of Variance explained by the final model**

In view of the random effects, we noticed a considerable reduction in the variance components at all levels after incorporating predictors. Table 11 below presents a comparison of the unconditional model random effects (model 1) and conditional model random effects (model 2). The columns labelled model 2 show the predicted variance of the level-three as 475.47 for Botswana, 2 420.99 for South Africa, and 806.21 for Zimbabwe (between school variance).

In model 2, the level-two random effects predicted a within-school-between classroom variance of 196.26, 103.38 and 925.00 for Botswana, South Africa and Zimbabwe respectively. The row labelled individual-level variance in Table 11 below, displays the estimated variance of the overall error term, or more specifically, it estimates the within-classroom-between-student variance of 3 969.32 for Botswana, 4 080.93 for South Africa, and 5094.13 for Zimbabwe.

**Table 11: Comparing null and full model variance parameter estimates**

	Botswana Models		South Africa Models		Zimbabwe Models	
	Null	Final	Null	Final	Null	Final
<b>School- level variance</b>	1711.25	475.47	5259.2	2420.99	3096.54	806.21
<b>Class-level variance</b>	215.62	196.26	160.39	103.38	1015.93	925.00
<b>Individual-level variance</b>	4489.43	3969.32	4303.23	4080.93	5490.75	5094.13

The school-level variances were reduced by 72.22% in Botswana, 53.97% in South Africa, and 73.96% in Zimbabwe. Class-level variances reduced by a much lesser magnitude of 8.98% in Botswana, 35.54% in South Africa and 8.95% in Zimbabwe. Individual-level variances were reduced by 11.59%, 5.17% and 7.22% respectively. This showed that inclusion of explanatory variables in the model significantly reduced variance amongst all levels, particularly at the school-level. At the class-level, a significant reduction was observed in South Africa, slightly reduced in Botswana, and an insignificant reduction was observed in



Zimbabwe. Including student-level variables does not reduce variances by a huge margin in all countries relative to other levels.

Although there was a considerable decrease in variances at all levels for all countries, proportions not explained by the full model still remained. This suggested that there were other variables that could have been included, perhaps to account for the remaining variance. Several variables could not be considered in this analysis even though they were in the dataset; the main reason being that they had too many missing points. In as much as they might have been of great interest, for example, as the literature review has shown, teacher gender had been seen to play a significant role on student achievement. Some studies have documented that in some areas: students of the same gender as their teachers have tended to excel in their studies compared to those of the opposite sex. However, this does not hold in other studies. It would have been interesting to have included an interaction effect on such gender related variables and to have observed their effect on student achievement.

Additionally, the fact that the research was based on secondary data also explains the failure to fully account for all the variance in the analysis. This was because there were some interesting variables that do not exist in the dataset, simply because they were not important for the original purpose of the data. A classic example is the absence of a race variable. It would have been interesting to observe its effect on student achievement, particularly in South Africa, which is struggling to redress the legacies of the past government that perpetuated great inequalities on racial grounds. Apartheid resulted in some races enjoying better educational facilities than others and as such it would be expected that student achievement would follow racial lines as well.

Furthermore, since SACMEQ is not a value-added and longitudinal study, its cross-sectional nature means that it is not possible to derive a prior achievement variable and observe

achievement over time. Thus the very nature of the data limits the ability to observe the effects of other likely important variables, hence the failure of this paper to fully account for most of the variance. Nevertheless, the fact that most of the variance between schools, classes and individuals was explained by variables included in this research means that the gaps between schools, classes and individuals in terms of student maths achievement can be attributed to these very variables.

## 5.6 The post-estimation ICC

In conditional models, ICCs are based on the residual rather than the observed responses and they measure the similarity in outcomes having adjusted for the predictor variables (the similarity in unexplained outcomes). This is the reason why they are also called adjusted or residual ICCs (Leckie, 2013). Table 12 presents the respective post-estimation ICCs.

**Table 12: Residual ICC**

<b>Intra-class correlation</b>	<b>Botswana</b>		<b>South Africa</b>		<b>Zimbabwe</b>	
	<b>Coefficient</b>	<b>S.E</b>	<b>Coefficient</b>	<b>S.E</b>	<b>Coefficient</b>	<b>S.E</b>
School	0.10	0.02	0.37	0.02	0.12	0.03
Class   School	0.14	0.02	0.38	0.02	0.25	0.02

**Note:** S.E=Standard Error

Comparing the post-estimation ICCs with the unconditional model's ICC, we would observe a considerable reduction, especially for Botswana and Zimbabwe. As was established in the null model, there is a fairly higher correlation on observations on students within the same classroom compared to that on students in the same school. The results show that 10 %, 37 % and 12 % of the unexplained variance in student scores in Botswana, South Africa and Zimbabwe, occurred between schools, respectively. The class-level ICC reveals that 14%, 38% and 25% of the unexplained variance occurred within-school-between classroom in Botswana, South Africa and Zimbabwe, respectively.

### **5.7 The Likelihood-ratio test (LR Test)**

Apart from the justifications made for employing a multilevel analysis in place of the traditional models discussed earlier, the full model's likelihood-ratio test results comparing the linear mixed-effects model with a one-level ordinary linear regression (a model without school or classroom effects/ without random effects) showed that the estimated model was more appropriate relative to OLS. The LR test statistics are Botswana ' $\chi^2(2) = 248.97$ ', South Africa ' $\chi^2(2) = 2635.41$ ', Zimbabwe ' $\chi^2(2) = 472.80$ ', all with p-values that are effectively zero ' $\text{Prob} > \chi^2 = 0.0000$ ' ( $p < 0.001$ , or more precisely  $p < 0.00005$ ). The three-level model therefore offered a significantly better fit to the data than a single-level model Leckie (2013). Therefore, based on these post-estimation test results, a three-level model was preferred to the single-level model for this analysis. We can therefore conclude that the sampled students did not act as independent observations and that students from the same school were significantly more alike. Similarly, students taught in the same classroom were significantly more homogenous than their schoolmates who were taught in separate classrooms, irrespective of the fact that they might have been in the same grade. In other words, the mathematics test scores varied significantly across schools and across classrooms.

## **Chapter Six**

### **Summary and Conclusions**

#### **6.1 Summary**

The purpose of this research was to explore the determinants of student achievement in three neighbouring Southern African countries, namely Botswana, South Africa and Zimbabwe. In the process, the paper would then bring out what best explained student achievement in all the three countries and compare them. The aim was to offer more insight into what could explain student achievement, in order to aid policymakers to devise more specific policies that would improve this achievement, and, considering the perennial financial constraints in public sector funding, with lower per dollar expenditure. Preliminary chapters contextualised the problem by summarising stylised facts about economic, demographic and student performance indicators in the three countries. The results of this contextual analysis showed that in terms of per pupil expenditure, South Africa devoted more to the education sector than either of the two other countries under study. It was also established that in terms of student performance, Botswana's students performed better in their primary leaving examinations, as on average, more than 60 % of Botswana's students passed all necessary exams. In Zimbabwe and South Africa however, very low performance was observed, with South Africa being the most affected.

The study proceeded to outline the theoretical context of the research, as it discussed the education production function as a key theoretical framework underpinning the research. Further, empirical literature was reviewed, paying close attention to the intentions of the researches reviewed, the variables, methodologies adopted, and the overall results. It was established that there was no consensus on what could better explain student achievement,

both within space and time. Results differed also as a result of methodologies adopted, data, country contexts and variables used. Informed by the reviewed literature, a multilevel model was adopted to estimate the determinants of student achievement using SACMEQ III data for Botswana, South Africa and Zimbabwe. This model was deemed appropriate because of its ability to take into account the hierarchical structure of this kind of data. Above that, the data enabled the researchers to ascertain how much of the variance our model had predicted and how much remained unexplained. Three levels, namely student, classroom and school were identified in the data and hence a 3-level model was adopted. The initial model that was estimated proved that the multilevel model was warranted as it also decomposed total variance into the three different levels. Proceeding with the estimation, it was shown that there were some variables that significantly explained student achievement across all countries, albeit in some instances with both differing magnitudes and signs. However, others were significant in certain countries, and insignificant in others.

Key findings of the research were that student achievement determinants vary between countries, though there are some variables that uniformly explain achievement across all the countries under study. Key results were the importance of a student's socio-economic background; ability to frequently speak the language of instruction; having a well-resourced school; and gender type. In the case of Botswana, results also showed that students enrolled in private schools, and that those with the relevant textbooks were predicted to do better than their counterparts. In Zimbabwe, additional variables such as class size, teacher qualification and enrolling for extra lessons significantly improved maths scores. A significant observation in the South African case was that of student class repetition and enrolling for extra lessons. Both these were seen to negatively affect student achievement. Comparing coefficients of the extra lesson variable with the repetition variable in South Africa could imply that *ceteris paribus*, students who repeat are worse-off than those who opt for extra lessons. However, the

Interaction effects results category did not bring many interesting results, except in the Zimbabwean and Botswanan data, which showed that female students seemed to perform lower than their counterparts in bigger classes, when in fact the individual variables showed that girls outperformed boys and that class size improves achievement in Zimbabwe. Also, interaction effects showed that females performed less well than boys in schools with superior resources in Zimbabwe.

Upon decomposing the post-estimation variances, it was observed that there was still some unexplained variance, though it had greatly reduced, especially in Botswana and Zimbabwe. Several reasons could explain the failure of the model to account for all the variance. Firstly, the researcher had to abandon quite interesting variables because of the extent of missing data in such variables. Previous researchers for example, have observed a strong link between student-teacher genders on achievement. Secondly, as the researcher used secondary research, it was collected for other purposes not necessarily specific to this research. Thus, in as much as it enabled the researcher to estimate these determinants of student achievement, it could have been more interesting if the research had been able to work with variables such as prior achievement, student motivation, race, and effects of culture and neighbourhoods. In previous analyses, all these have been observed to greatly influence achievement. Such variables could have better enabled the analysis to better explain the variance. Lastly, if this study had been longitudinal rather than a cross-sectional study, it could have enabled the researcher to observe student performance across time, as contexts greatly change with time. Nonetheless, the research has accounted for most of the variance and has to an extent shed light on the probable determinants of student achievement in Botswana, South Africa and Zimbabwe.

## 6.2 Conclusions

The findings bring out the need for stakeholders to be cognisant of the possibility that students from well-resourced families already have an advantage in achievement scores. Therefore it is important that we find strategies to ensure that students from poorer backgrounds are compensated in some way to make up for this loss in advantage. This could be the reason why school feeding schemes have been introduced in some parts of the world. Similarly, because the language of instruction plays a critical role in student achievement in the three countries under study, it is of great concern when considering that to many of the students, the English language is exotic. Ways must be found to ensure that students are able to learn using a language that they are comfortable with, and ways of improving their ability to grasp the language of instruction. In the same vein, having realised that engaging in extra lessons better predicts student achievement relative to repetition, it would be interesting to establish the reason why this could be so. Uncovering such finer processes would also enable policymakers and other strategists to better target resources in order to maximise student achievement.

It is indeed logical to find that having math textbooks positively influences achievement. However, in South Africa, the analysis found no evidence for the assertion that students with textbooks perform better than those who do not have them. Perhaps this could be influenced by the possibility that certain children are not able to read or comprehend, and this hinders them in learning on their own.

One of the many contentions in achievement literature is the effect of class size on student achievement. There were mixed results in this regard, but based on this paper's overall results, these further add to the discourse. What these results could imply is that context matters. In Botswana, the estimation results showed that private schools have been estimated to significantly influence student achievement. For public schools to operate on a par with

private schools a proper analysis would be necessary of the processes, culture, general load and all things that are prevalent in private schools but absent, or least emphasised, in public schools. In a way this would ensure that only the ownership structure would be different for private and public schools.



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**APPENDIX I: Mean student mathematics performance in the SACMEQ III study.**

<b>Country</b>	<b>Boys</b>	<b>Girls</b>	<b>Rural</b>	<b>Urban</b>	<b>Low SES (Bottom 25%)</b>	<b>High SES (Top 25%)</b>	<b>Overall</b>
<b>Botswana</b>	<b>517.5</b>	<b>523.6</b>	<b>501.1</b>	<b>538.8</b>	<b>479</b>	<b>553.1</b>	<b>520.5</b>
<b>Kenya</b>	567.6	546	544.5	580	540.9	595.8	557
<b>Lesotho</b>	477.1	476.8	469.3	492	460.2	498.3	476.9
<b>Malawi</b>	452.7	441.1	443.7	457.6	444.7	454.4	447
<b>Mauritius</b>	616.1	630.7	613.2	634.1	554.2	719.2	623.3
<b>Mozambique</b>	488.2	478.6	477.6	487.5	470.8	510.8	483.8
<b>Namibia</b>	472	470.1	448.5	506.1	443.7	513.5	471
<b>Seychelles</b>	535.2	566.7	550.2	550.9	498.7	593.6	550.7
<b>South Africa</b>	<b>491.2</b>	<b>498.4</b>	<b>456.7</b>	<b>533.1</b>	<b>446.2</b>	<b>578.6</b>	<b>494.8</b>
<b>Swaziland</b>	545.5	536.2	535.6	552.9	533.4	552.4	540.8
<b>Tanzania</b>	568.5	537.5	542.1	575.7	540.4	579.4	552.7
<b>Uganda</b>	486.7	477.2	470.8	511.5	465.4	504.2	481.9
<b>Zambia</b>	440.8	429.2	428.6	447.2	424.5	463.1	435.2
<b>Zanzibar</b>	489.3	483.9	477.8	500.5	471.1	510	489.9
<b>Zimbabwe</b>	<b>520.8</b>	<b>519</b>	<b>492.1</b>	<b>589.6</b>	<b>487.8</b>	<b>588.8</b>	<b>519.8</b>
<b>SACMEQ III</b>	<b>511.9</b>	<b>507.6</b>	<b>493.9</b>	<b>533.2</b>	<b>488.7</b>	<b>541.7</b>	<b>509.7</b>

APPENDIX II-A: Correlation matrix between variables for Botswana

	Mathematics Score	Female	Repetition	Extra Lessons	Speaks instructional language	Socio- economic Status	Textbook	Class Size	Teacher Qualifications	Private School	School Resource
Mathematics	1										
Female	0.043	1									
Repetition	-0.258	-0.140	1								
Extra lessons	0.030	0.012	-0.012	1							
Speaks instructional	0.254	0.053	-0.110	0.029	1						
Socio-economic Status	0.441	0.004	-0.158	0.0574	0.308	1					
Textbook	0.095	0.034	-0.063	-0.037	0.032	0.010	1				
Class size	0.040	0.000	-0.016	-0.028	0.120	0.190	0.076	1			
Teacher qualifications	0.096	0.010	-0.047	0.019	0.046	0.081	-0.039	0.042	1		
Private school	0.357	0.006	-0.050	-0.058	0.084	0.379	0.003	-0.00	0.065	1	

**APPENDIX II-B: Correlation matrix between variables for South Africa**

	Mathematics Score	Female	Repetition	Extra Lessons	Speaks instructional language	Socio-economic Status	Textbook	Class Size	Teacher Qualifications	Private School	School Resource
<b>Mathematics Score</b>	1										
<b>Female</b>	0.035	1									
<b>Repetition</b>	-0.247	-0.142	1								
<b>Extra lessons</b>	-0.006	0.011	0.025	1							
<b>Speaks instructional language</b>	0.231	0.056	-0.113	0.027	1						
<b>Socioeconomic Status</b>	0.480	0.023	-0.207	0.012	0.238	1					
<b>Textbook</b>	0.058	0.007	0.012	0.014	0.059	0.049	1				
<b>Class size</b>	-0.174	0.008	0.040	-0.029	0.017	-0.098	-0.042	1			
<b>Teacher qualifications</b>	0.138	0.001	-0.084	-0.002	0.049	0.110	0.031	-0.116	1		
<b>Private school</b>	0.010	0.008	-0.016	-0.055	-0.011	-0.016	-0.003	-0.064	0.034	1	
<b>School Resource</b>	0.4458	0.0111	-0.142	-0.013	0.188	0.476	0.075	-0.157	0.102	-0.023	1

**APPENDIX II-C: Correlation matrix between variables for Zimbabwe**

	Mathematics Score	Female	Repetition	Extra Lessons	Speaks instructional language	Socio-economic Status	Textbook	Class Size	Teacher Qualifications	Private School	School Resource
<b>Mathematics Score</b>	1										
<b>Female</b>	0.007	1									
<b>Repetition</b>	-0.258	-0.083	1								
<b>Extra lessons</b>	0.183	0.015	-0.022	1							
<b>Speaks instructional</b>	0.289	-0.005	-0.079	0.167	1						
<b>Socioeconomic Status</b>	0.393	0.014	-0.138	0.277	0.316	1					
<b>Textbook</b>	0.105	0.052	-0.077	0.141	0.062	0.183	1				
<b>Class size</b>	0.168	-0.030	-0.065	0.165	0.072	0.221	0.011	1			
<b>Teacher qualifications</b>	0.032	0.017	-0.034	-0.004	-0.041	-0.003	-0.0048	0.108	1		
<b>Private school</b>	-0.126	-0.001	0.039	-0.176	-0.051	-0.224	-0.072	-	0.013	1	
<b>School Resource</b>	0.404	-0.034	-0.1578	0.228	0.284	0.500	0.172	0.073	0.067	-0.263	1