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JEL: C10, H52, I21

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ABSTRACT

This study explores the important relationship between policy variables that represent a school's human resources and product variables in the form of student performance in Botswana's schools. A focus of particular interest is if the teaching environment is related to student success and whether it can promote equity in learning between students from different socioeconomic backgrounds. Data for the study are drawn from a rich survey of students, teachers and schools in Southern and Eastern Africa. There is modest evidence to suggest that students attending well resourced schools are likely to perform better, irrespective of their background. The results points to a clear association between teacher content preparation and student achievement. Regular assessment is associated with better performance and greater social equity between students within the same school. Policy implications related to teacher preparation programmes in Botswana are discussed.

Keywords: Botswana, education production function, demand for schooling, teacher evaluation, teacher knowledge, teacher education
JEL codes: C10, H52, I21

1. Introduction

This study investigates the relationship between teaching inputs and pupil performance in the Botswana state-run education system. Although Batswana children have ready access to free primary education, improving its quality and relevance remains central to the government's planning strategies (Government of Botswana 1993; Government of Botswana 1994). Policy practitioners recognise that to achieve success at higher levels of study, a solid foundation of primary education is essential (Government of Botswana 1996). Typically, educational studies in developing countries concentrate on how material inputs contribute to student success. Crucial to this line of research is the relationship between resource availability and the distribution of educational outcomes across schools. Studies of this nature pursue a link between the quality and quantity of school resources and the performance of students within a school (Barr and Dreeben 1983; Entwisle, Alexander, and Olson 1997; Hanushek 1996; Hedges and Greenwald 1996; Hedges, Laine, and Greenwald 1994; Wößmann 2000).

Although the backdrop remains the same, the focus of this study is on the processes operating within Botswanan classrooms and how they influence learning outcomes. Both researchers and policy planners agree that ensuring effective learning must address what teachers know (as defined by their subject matter knowledge) and how they transfer this knowledge through their choice of teaching inputs (Barr and Dreeben 1983; Government of Botswana 1993). Technically competent teachers who are unable to organise the teaching process appropriately may fail to translate their qualifications into discernible learner gains. Conversely, suitable methodologies will achieve little if teachers are inadequately trained (Lortie 2002).

In the following section, we will provide a brief introduction to the study area and its education system. This is followed by a review of the literature and an introduction to the analytic method that is applied later. The empirical results include a discussion of how the characteristics of students relate to academic achievement. Because our primary intent is to identify effectiveness enhancing qualities of the school, the main discussion will centre on the school and teaching environment. A discussion of the policy relevance of the findings is provided at the end of the paper.

2. Introduction to the Study Area

Situated in Southern Africa, with a population of 1.5 million, Botswana is one of the most sparsely populated countries in the region. The Kalahari Desert dominates the landscape and covers 70 per cent of the country's surface area. At the time of independence from British colonial rule, Botswana was one of the poorest countries in the world. Since then, the country's economic growth has been steady and impressive. Botswana's political transparency and stable investment climate are widely acclaimed. It has sustained an impressive level of economic growth, comparable to high performing emerging economies (World Bank 1999). The country was the world's fastest growing economy between 1966 and 1989 (Harvey 1992).

The Botswanan economy is heavily dependent on mining and on diamonds in particular with a third of GDP sourced from the mining industry in 2005 (World Bank 2007). Other important sectors are beef production and tourism. Government attempts at economic diversification have achieved very limited success and diamond mining is expected to be the chief source of government revenue for the foreseeable future. A possible implication of over-reliance on mining output is a situation referred to as 'Dutch Disease'. In the economics literature, this phenomenon occurs when an increase in the export of natural resources leads to a dramatic rise in national income. It follows that other sectors such as manufacturing and agriculture are stifled because a stronger local currency reduces their price competitiveness. In the case of Botswana, it has often been remarked that the boom in diamond mining effectively constrained the development of the agricultural industry (Love 1994; Mogotsi 2002) with far reaching effects on rural poverty and development (Clover 2003). Other researchers take the view that Botswana averted the resource curse experienced by many mineral rich countries because of close attention to good governance and fiscal discipline (Harvey 1992; Iimi 2006). Harvey (1992) would add that efforts at expanding the formal sector in both rural and urban areas also contributed to sustained economic growth .

Government consists of an elected legislature and a separate House of Chiefs that provides direction on traditional matters (Kgomanyane 1994). Arguably more steeped in tradition than its neighbours, the majority of Batswana live in rural areas. About 80 per cent of the population belong to the Tswana ethnic group although there are 28 additional

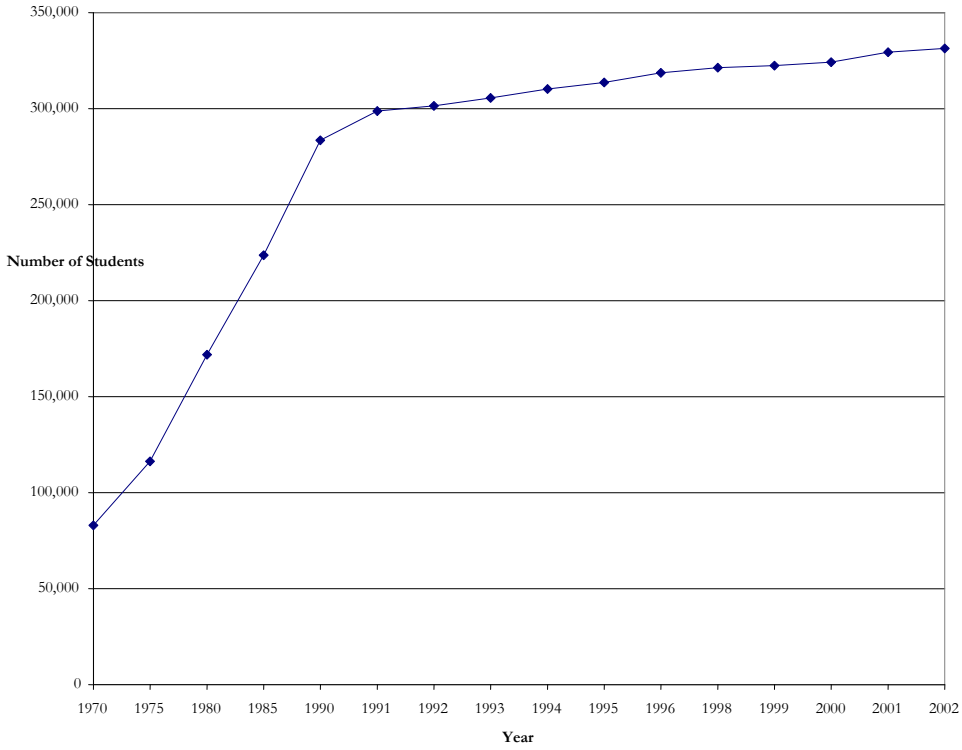
language groups. One of the major challenges facing the country is the high incidence of HIV/AIDS among the working age population. The teaching profession has been one of the worst hit. However, Botswana is unique in offering free medical treatment to its citizens. A concerted effort has been made to reach teachers affected by the disease (Government of Botswana 1993).

2.1 Education in Botswana

The structure of the Botswana education system consists of seven years of primary school (Standards 1 to 7), three years of junior secondary (Forms 1 to 3) and two years of senior secondary schooling (Forms 4 and 5). Over the last four decades, improving access to education has been at the forefront of government policy (Ministry of Education 2005). Education is free, although parents are expected to make a contribution to the school's feeding programme. Botswana has one of the highest Net Primary Enrolment Ratios in the region[1]. Figure 1 depicts the growth in the primary school student population between 1970 and 2002. The sharp increase in the 1980s is likely due to the removal of primary school fees in 1980. Although primary education is free, it is not compulsory and a small percentage of students still remain out of school.

[1] The Net Primary Enrolment Ratio compares the number of children of primary school going age who are enrolled in primary school to the total number of children of primary school going age in a country's population.

Figure 1: Growth of Botswana Primary Level Student Population

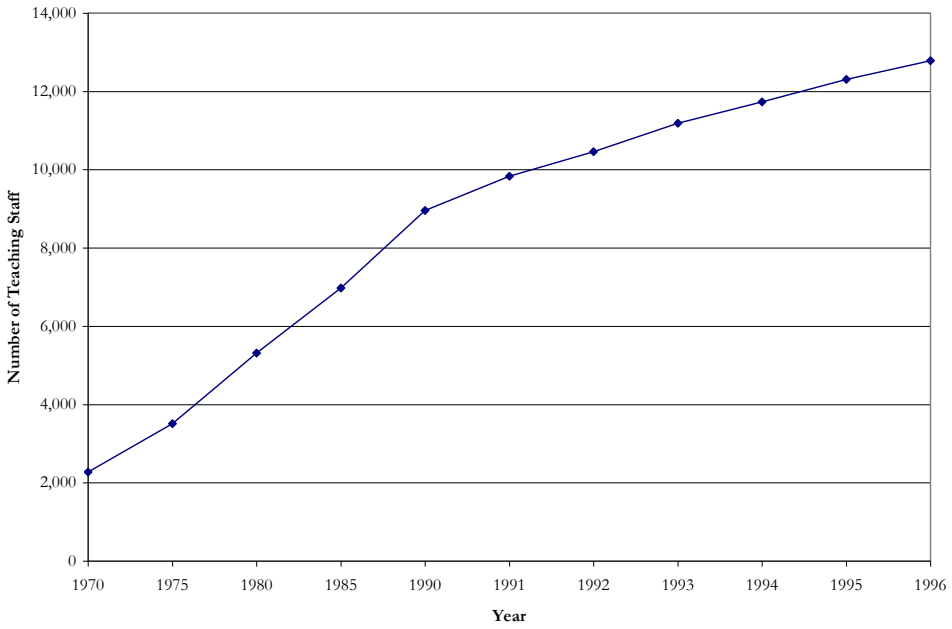


In the 1990s, government expenditure on education constituted about one-fifth of total government spending. In 1999, 25 per cent of the national budget was allocated to education (Keitheile and Mokubung 2005). Free education in Botswana covers tuition fees, teaching and learning materials, co-curricular activities and boarding (if students are not in day schools). The supply of specialised equipment such as computers, televisions and photocopiers are left to Parent-Teacher Associations (PTAs) in each school. The Ministry of Local Government and Housing is responsible for teacher housing, school infrastructure, furniture and textbook distribution (Keitheile and Mokubung 2005). The introduction of a feeding programme has been immensely successful and is credited with improving attendance rates in many parts of the country. Student participation remains a problem in certain pockets of the country, such as the Western region. The semi-nomadic lifestyle of these communities often means that students spend extended periods of time out of school. Students write national examinations at the end of Standards 4 and 7. The Primary School Leaving Examination (PSLE) at the end of Standard 7 is essentially a diagnostic tool for teachers and parents and does not prevent progression to secondary

school (Ministry of Education 2005). Students are examined in seven subjects: English, Setswana, Mathematics, Science, Social Studies, Agriculture and Moral Education. Primary school students are taught in a local language from Standards 1 to 4. English is the formal medium of instruction from Standard 5 onwards (Kgomanyane 1994).

Improving teacher quality is another pressing challenge and one that government recognises (Government of Botswana 1993). At the time of independence, only two teacher training colleges existed nationwide (Masaila 2008). The number of teachers has rapidly expanded over the last three decades (see Figure 2 below). What is not depicted in the graph is teacher scarcity in a number of technical subjects including maths, physics and chemistry. Although the Revised National Policy on Education (RNPE) recommends subject specialisation, the vast majority of primary school teachers in Botswana are generalists. This implies that they may be assigned to teach subjects in which they are not necessarily conversant.

Figure 2: Growth in Botswana Teaching Staff



To improve the quality of primary school instruction, entry requirements for teacher training colleges have been raised and the duration of teacher training extended (Government of Botswana 1993). In the 1980s, as part of the Primary Education

Improvement Project (PEIP), staff at teacher training colleges received further education at the University of Botswana (Craig, Kraft, and du Plessis 1999). Plans are also underway to raise the status of the teaching profession by bringing the non-monetary benefits of teachers in line with other public sector jobs (Government of Botswana 1994). Previously a primary school certificate was sufficient to gain entry into primary teacher training colleges. More recently candidates are expected to obtain a junior certificate (three years of secondary school) and study for three years in order to graduate with a Diploma in Primary Education (Keitheile and Mokubung 2005). At the junior secondary level, the pre-requisite for teacher training is the completion of five years of secondary school. Most junior school students are taught by teachers who have spent three years in teacher training colleges and who have graduated with a Diploma in Education (Ministry of Education 2005). Teachers specialise in two subjects at teacher training college. Interestingly, according to the recent TIMMS study, there was no performance advantage in mathematics for students taught by teachers specialising in that subject (Ministry of Education 2005).

3. Theoretical Framework

Botswana is exceptional in offering free universal primary and secondary education. The country's commitment to universal education preceded the more frantic efforts pursued by a number of countries decades later. Mass education policies have raised difficult questions about how to accommodate additional students within schooling systems that are already strained to capacity (Deininger 2003; Mosha 1988; Ross 2007; UNESCO 2006). The worst consequences of low quality schooling are often borne by the children that these policies were originally designed to protect (Hanushek 1995; Lockheed and Levin 1993). Students from less favourable home environments face greater academic challenges. There are added demands on children's time and a notable absence of adult academic support. In spite of the extra effort required to educate children who are at higher risk of failure, some schools manage to do so successfully. In such schools, not only are educational standards generally high, but achievement differences between students of different backgrounds are reduced. We begin this section by discussing some key student inputs, focusing on their social and academic background because these factors shed light on how prepared students

are for schooling. Thereafter follows a review of the literature with a focus on how teacher quality and teaching methodologies have been shown to influence academic quality and equality in schools. Although we single out important international research, we pay close attention to studies carried out in developing countries.

3.1 Student Background and Academic Success

The influence of a student's socioeconomic status on academic achievement is important for many reasons. It identifies the out-of-school environment that the student encounters and the resources available to support learning. Students with a stronger support system at home are more likely to perform well at school and are subsequently presented with better opportunities later in life. Variations in social support structures exist in all countries but because of widespread poverty in low-income countries, the influence of the home setting on academic achievement tends to be less varied there. In their seminal study of school effects on academic achievement in developing countries, Heyneman and Loxley concluded that the poorer a country, the weaker the influence of student social status on academic achievement (Heyneman and Loxley 1983). This finding has been challenged recently, particularly in countries where mass education drives have increased the social diversity of the student population (Baker, Goesling, and LeTendre 2005; Zuze 2008). Irrespective of a country's economic circumstances however, an unsupportive environment at home will inevitably interfere with children's scholastic development. Related to the home environment are student attitudes about their ability to succeed at school. It has been shown that low levels of self confidence will influence the way pupils address their daily tasks, especially in maths and science subjects (Multon, Brown, and Lent 1991). These perspectives are jointly formed in the home, at school and in the communities where students reside. At times children are socialised to believe that success in certain subjects is beyond reach. Student motivation declines and this is reflected in their performance at school (Adams 1984; Fennema and Sherman 1977; Keeves and Kotte 1992).

Seeking answers to questions about educational opportunity led to many seminal studies of educational quality. Two of the most influential examples are the 1966 Coleman Report in the United States and the 1971 Plowden Report of children in

England and Wales (Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld, and York 1966; Peaker 1971). Because the authors concluded that the influence of a student's home environment overshadowed the impact of the school, they sparked decades of debate about how educational reform should be shaped, which led to the growth of school effectiveness research. The issue remained unexplored in developing countries until Heyneman's research into Ugandan primary schools demonstrated that school effects were the dominant influence on educational quality (Heyneman 1976; Heyneman 1976; Heyneman 1977; Heyneman 1979). The point to emphasise is that socioeconomic status remains a factor of educational research, and although its influence may vary from country to country, it must be estimated with accuracy if school effects are to be understood.

Grade repetition is another important indicator of academic strength (Entwisle, Alexander, and Olson 1997; Hanushek 1995). It occurs when students begin an academic year in the same grade as the previous year instead of advancing to the next grade level. According to Lockheed and Levin (1993), compared to developed nations, the likelihood of repetition is almost five times higher in less developed parts of the world. Grade repetition can also be influenced by national policy when regulations about automatic promotion are enforced so that unprepared students advance to the next grade level. Grade repetition is frequently associated with low socioeconomic status and with absenteeism (Brophy 2006). Repetition in Botswana is known to be more common among orphans (CfBT Education Trust 2008) and to be related to teenage pregnancy (Meekers and Ahmed 1999). Typically students who repeat a grade do so in the early years of primary school. In developing countries this is especially common if students are unfamiliar with the language of instruction.

In some African countries, repetition rates in the later stages of primary schooling are related to national examination policies. Either parents or school principals encourage repetition if there is reason to believe that the student will be unsuccessful in primary leaving examinations. In countries where these results are made public, and a school's reputation is at stake, pressure on academically weak students to repeat the later grades of primary school tends to increase (Abagi and Odipo 1997; Acana, Kyagaba, and Opaman 2003). Parents may support a decision for their children to repeat if they think it will

improve their chances of attending a good secondary school. If students are forced to repeat a grade, this can lead to overcrowded classes and overstretched resources because students who are on grade level for their age will have to make room for students who are held back (Tarumi 2010). Therefore even students who have not repeated a grade are indirectly affected by a school's repetition practices.

There is some evidence of a positive relationship between student grade repetition rates and individual student test scores (Gomes-Neto and Hanushek 1994) indicating that higher repetition rates can be associated with achievement gains for the school as a whole (Lee, Zuze, and Ross 2005; Zuze 2008). These short term gains are mostly the result of students revising familiar material. In the long-run, as these students advance to higher grades and are faced with more difficult aspects of the school curriculum, the negative impact of repetition on performance begins to surface (Brophy 2006). Many studies have linked repetition practices to poor academic performance and to students dropping out of school (Haddad 1979; Jackson 1975; Westbury 1994). This has led critics of this policy to suggest that the costs of repetition far outweigh the benefits (CfBT Education Trust 2008). It should also be apparent that as an estimate of academic background, repetition is an important dimension of educational quality not to be overlooked.

3.2 Quality Teachers and Quality Schooling

Research into whether and to what extent the quality of teachers matters in African schooling systems has started to receive considerable attention. Many governments are overwhelmed by severe teacher shortages for state-owned schools. Most would agree that a better understanding of where teacher competency is greatest will assist in the design of teacher preparation programmes (D'Agostino and Powers 2009; Rockoff, Jacob, Kane, and Staiger 2008). Pressure to lower entry requirements for teacher training programmes is high. Understanding which kinds of teachers make the greatest difference to student success increases the possibility of preparing new teachers more adequately. Estimates of teacher quality in developing countries have tended to be quite crude. Information on teacher experience and education levels is fairly common but what these variables actually translate to can vary significantly depending on local conditions. Better student performance seems to be strongly associated with teachers who

have higher professional and academic qualifications (Fuller 1987; Heyneman and Loxley 1983). In their review of Latin American studies, Velez and colleagues noted that although teacher qualifications seemed to matter, levels of in-service training had no systematic influence on student achievement (Velez, Schiefelbein, and Valenzuela 1993). A remarkably similar conclusion was found by Duthilleul and Allen in their investigation into Namibian teacher effectiveness (Duthilleul and Allen 2005). The latter study also found that teacher training was especially effective in more affluent schools.

Park and Hannum's analysis of Chinese education data found that teacher characteristics explained a large proportion of the heterogeneity in student achievement, a result that held in different subject areas (Park and Hannum 2001). The few studies that directly assess teacher competency have found a very strong relationship between teacher subject matter knowledge and student achievement (Fuller, Dellagnelo, Strath, Bastos, Maia, De Matos, Porterla, and Viera 1999; Heyneman and Jamison 1980; Lee, Zuze, and Ross 2005; Mullens, Murnane, and Willett 1996). Lee et al. (2005) used a unique construct of teacher quality that combined information on teacher professional and academic experience and subject matter knowledge. They dicovered a strong relationship between teacher quality and reading literacy in four out of fourteen African countries, over and above the influence of school and teaching resources.

It is slightly surprising that with such a robust measure of teacher quality, it had significant impact in only four countries. There are a number of possible reasons for this result. First, variability in teacher quality differed from country to country. Second, the fact that data were cross-sectional and not longitudinal would have suppressed the measurable effect of teacher quality. Studies in other regions of the world have shown that an effective teacher may be unable to reverse the damage of an ineffective one in a short period of time. Finally, it is possible that the relationship between teacher quality and student test scores was non-linear and made more of a difference for some students than for others depending on their ability level. These reasons then raise the question of whether teacher quality can be improved through incentive structures. If it can, teachers who have lighter loads and are better paid will be more motivated to teach (Chisholm, Hoadley, wa Kivulu, Brookes, Prinsloo, Kgobe, Mosia, Narsee, and Rule 2005; Vegas

and Umansky 2005). Results on the relationship between teacher salaries and academic achievement are inconclusive (Fuller 1987; Park and Hannum 2001).

Schools with teachers who take personal responsibility for the progress of their students and are committed to improving each student's performance tend to be more effective and more equitable than schools with less dedicated staff (Lee 2001). The climate of discipline and the ability to limit absenteeism are also elements of this type of commitment. Although decisions about the length of the school day are often determined by external policy, other issues related to attendance and the disciplinary climate vary considerably across schools (Dreeben and Barr 1987). Fluctuation in attendance and time wasted on unrelated tasks (such as resolving student disputes) will have a negative impact on the quality of learning. Previous studies have demonstrated that after adjusting for student socioeconomic status, there is a strong relationship between student attendance and student test scores (Fogelman 1978). There is also evidence that regular attendance and uninterrupted instructional time improve student performance (Anderson, Ryan, and Shapiro 1989). Research suggests that the importance of instructional time and achievement is particularly strong in high performing schools (Fredrick 1980). A study of OECD countries also noted a strong negative correlation between academic achievement and frequent student disruptions (Jürges and Schneider 2004).

Decisions about instructional time and other activities that take place within the classroom can also be influenced by a number of other factors. A diversity of teaching behaviour may exist within the same school, depending on the grade being taught and the nature of the curriculum. For example, students in grades where national assessment exams are administered are more likely to be drilled for the examination. In their study of Botswanan primary and junior secondary schools, Fuller and Snyder also observed that differences existed depending on the subject being taught (Fuller and Snyder 1991). Moreover, in a country with a high percentage of expatriate staff at the time, the authors noted that variation was partly driven by how foreign teachers were trained in their country of origin.

4. Methodology

Multilevel modelling is used to analyse the SACMEQ and TIMMS datasets. Multilevel analysis (also referred to as Hierarchical Linear Modelling or HLM) is a statistical technique often applied to research in the social sciences when data have a nested structure (Bryk and Raudenbush 1992; Hox 2002; Snijders and Bosker 1999). The use of multilevel modelling in this study is necessary for two reasons that relate to the research themes raised and the data used. First, all of the research questions that we pursue focus on how characteristics of schools might influence students' achievement. We investigate which elements of the school domain are related to a) raising student performance in curriculum-based tests and b) reducing inequality in student achievement between students of different backgrounds within the same school. Second, the data used to address the topics of educational quality and distributional equity are hierarchical.

The SACMEQ and TIMMS surveys collected information on students who were enrolled in specific schools and therefore the data possess a natural hierarchy. Some of the variables that we use refer to students (socioeconomic status, self-confidence and repetition history). There are other variables that are aggregated from student variables (the average socioeconomic status of students or the percentage of repeaters). Still other variables directly reflect the conditions of the school (such as the availability of resources, or the location of the school). As a statistical tool, HLM overlaps with traditional regression in some ways but it goes further to correct for many of its limitations (Heck and Thomas 2000).

There are a few key differences between the TIMMS and SACMEQ surveys that are worth mentioning. The SACMEQ survey was conducted in 2000 and targeted Standard 6 students in 15 education systems across Southern and Eastern Africa. After schools were sampled with a probability proportional to their size, a simple random sample of 20 Standard 6 students were selected within each school. The TIMMS survey was administered in 46 countries, mostly outside Africa, and the target population was students who had completed eight years of schooling. An intact class rather than a random sample of students was surveyed in TIMMS. The maths achievement variable available in the SACMEQ data was IRT scaled and standardised to a mean of 500 for all SACMEQ countries and a standard deviation of 100. The maths achievement variable in the TIMMS

data consisted of 5 plausible values for each student. used an iteration process that made use of all five plausible values in estimating the achievement outcome. The interpretation of the outcome variable is essentially the same. Botswana's average mathematics test score for SACMEQ was 521 or 0.21SD above the average for the entire SACMEQ group. Similarly, the overall score for Botswana students in TIMMS 2003 was 366 or 1.34SD below the mean for the set of countries in the TIMMS survey.

Research Questions

Three research questions guided the analysis conducted in this study. They are as follows:

Question 1: How is social and academic background of Batswana students related to their academic achievement? Does the relationship between background and achievement vary according to the schools that children attend?

Question 2: How do a school's teachers influence academic achievement, once we account for the students' social and academic background, the social composition and the resource base within the school?

Question 3: How do a school's teachers influence the distribution of academic achievement by their family social background, once we take into account other school factors? Do elements of the instructional process explain the achievement gap between repeaters and non-repeaters?

5.0 RESULTS

5.1 Results of the Descriptive Analysis

Variables Describing Students

Before turning to the multivariate analysis, it is useful to examine the descriptive evidence on students and schools in the Botswana education system. To ease the discussion details about the construction of variables have been relegated to Appendix 1. As far as possible the measures were constructed to improve comparison between SACMEQ and TIMMS. In Table 1 we show the average academic achievement classified by the socioeconomic background of Standard 6 and Form 1 students respectively. Unsurprisingly, test scores tend to increase with student wealth. There is a 0.7SD difference in achievement scores between the top and bottom wealth quintiles of Standard 6 students, and a 0.5SD differential in Form 1. On the surface this result may seem fairly typical because it is widely known that a student's social background is an important ingredient in

academic success. The fact that this effect surfaces in a developing country might be surprising. It is less so if we consider that with such a high level of enrolment, schools in Botswana are likely to have a greater social mix of students than elsewhere in the region. It does, however, suggest that social policies designed to compensate for wealth gaps between students cannot fully counterbalance the benefits of private educational investments and home background.

Table 1a: Standard 6 Mathematics Achievement by SES Quintiles (SACMEQ)

SES Quintile	Average Mathematics Score	Std. Deviation
1 (Bottom)	489.36	74.09
2	501.68	73.30
3	503.02	71.44
4	511.28	76.24
5 (Top)	562.24	95.48
Total	512.87	82.14

Table 1b: Form 1 Maths Achievement by SES Quintiles (TIMMS)

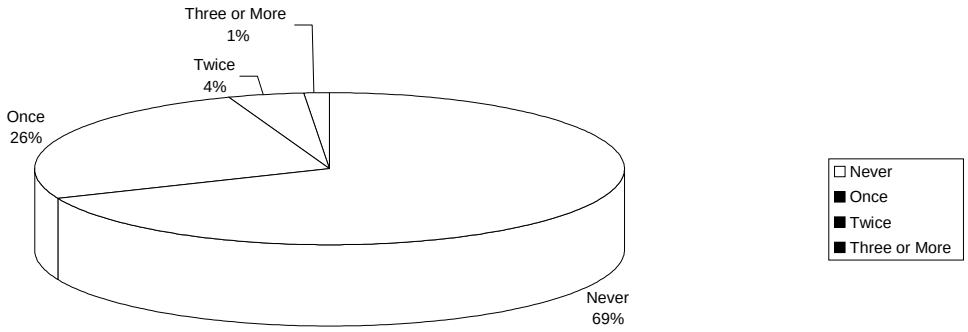
SES Quintile	Average Mathematics Score	Std. Deviation
1 (Bottom)	343.82	58.32
2	357.83	57.67
3	367.70	62.25
4	365.98	63.94
5 (Top)	390.80	68.30
Total	364.80	64.18

Figure 2 provides some preliminary insights into patterns of repetition in Botswana from the SACMEQ II survey[2]. About one-third of primary school students have repeated a standard at least once. Official guidelines indicate that repetition should not exceed 13 per cent in any given standard but there are no limitations to how many times an individual student can repeat. The vast majority of repeaters have repeated only one standard with only 5 per cent having repeated two or more times. It would be useful to isolate exactly which standards students repeat because determinants of repetition differ somewhat at the early and late stages of primary school. The only information available in the SACMEQ data archive relates to whether a student repeated Standard 6; the testing grade for the SACMEQ student assessment. Only 6 per cent of students repeated

[2] The TIMMS student questionnaire did not collect information on repetition history

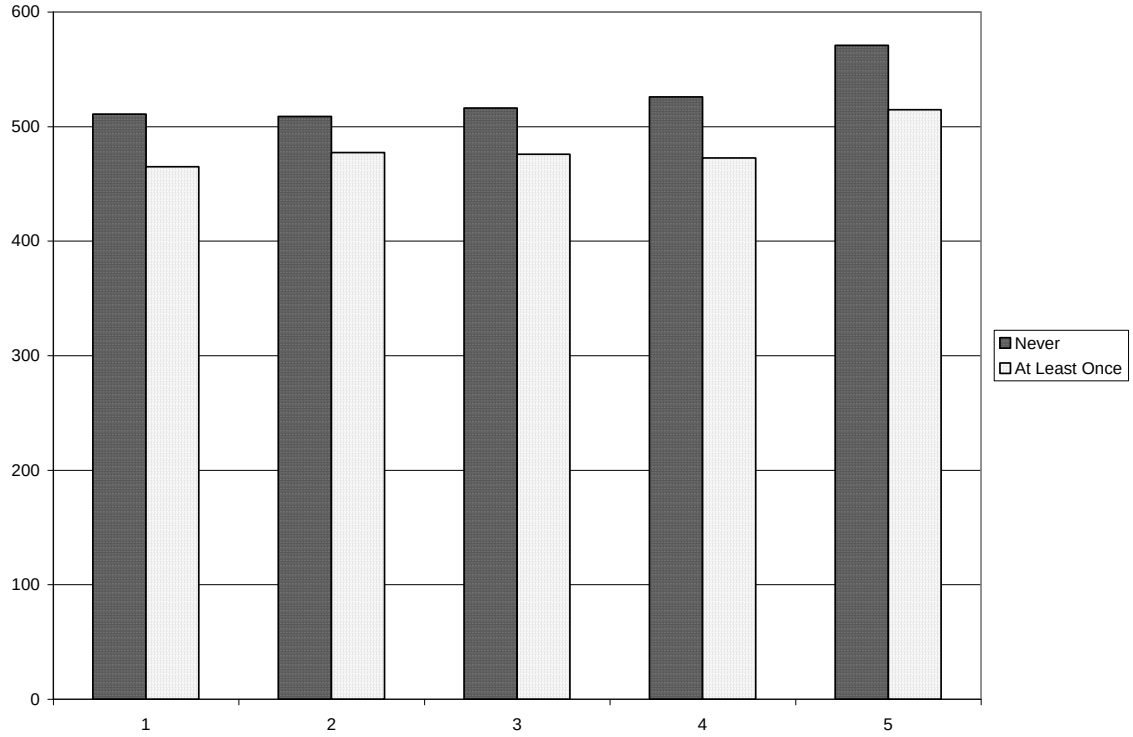
Standard 6. This would suggest that the vast majority of repetition is at earlier stages of the primary school cycle.

Figure 2: Percentage of Standard 6 Students who have Repeated a Standard



If we consider scores across wealth quintiles (Figure 3) by whether students have repeated, an interesting pattern emerges. Non-repeaters consistently outperform repeaters by about one half of a standard deviation, irrespective of which socioeconomic group one is comparing. Non-repeaters outperform their socio-economic peers in each instance.

Figure 3: Performance by Repetition History and Wealth Quintile in SACMEQ II

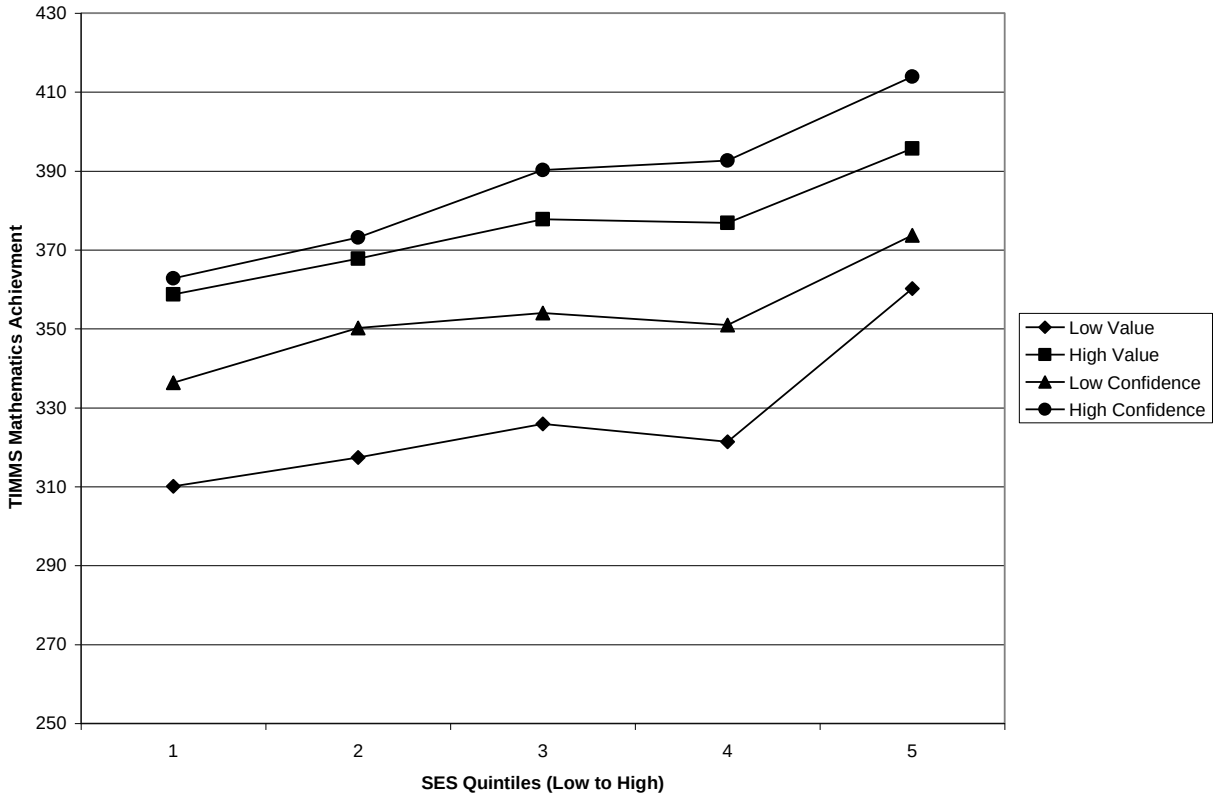


In Figure 4 we explore how self-reported attitudes about mathematics relate to performance in maths based on the TIMMS data[3]. Students are grouped according to their socioeconomic status. As mentioned earlier, there is increasing evidence that student perceptions about their own ability will be reflected in their performance at school. Equally the value they attach to their studies tends to influence the effort they invest in their scholastic development. A number of interesting points about this graph are worth pointing out. Across socioeconomic groups, students who attach little value to mathematics consistently achieve the lowest marks. Students who report that they feel confident in their ability to excel in mathematics generally perform better. The achievement differentials between students with different attitudes about Mathematics tend to increase at higher SES levels, meaning that differences are more pronounced among more affluent, high performing students and less apparent for low-income students. There is a slightly stronger effect related to value beliefs about mathematics compared to self-confidence in the subject. Clearly the direction of causality cannot be

[3] The SACMEQ II survey did not include information on student attitudes about their academic work.

determined with the cross-sectional data available for this enquiry. It may well be that students who have achieved success in mathematics tend to be more confident about their ability. In the same way, high performers could be more inclined to value the contribution of mathematics to their future undertakings.

Figure 4: Achievement by Student Attitudes about Mathematics and Wealth Quintiles in Botswana Junior Secondary Schools in TIMMS

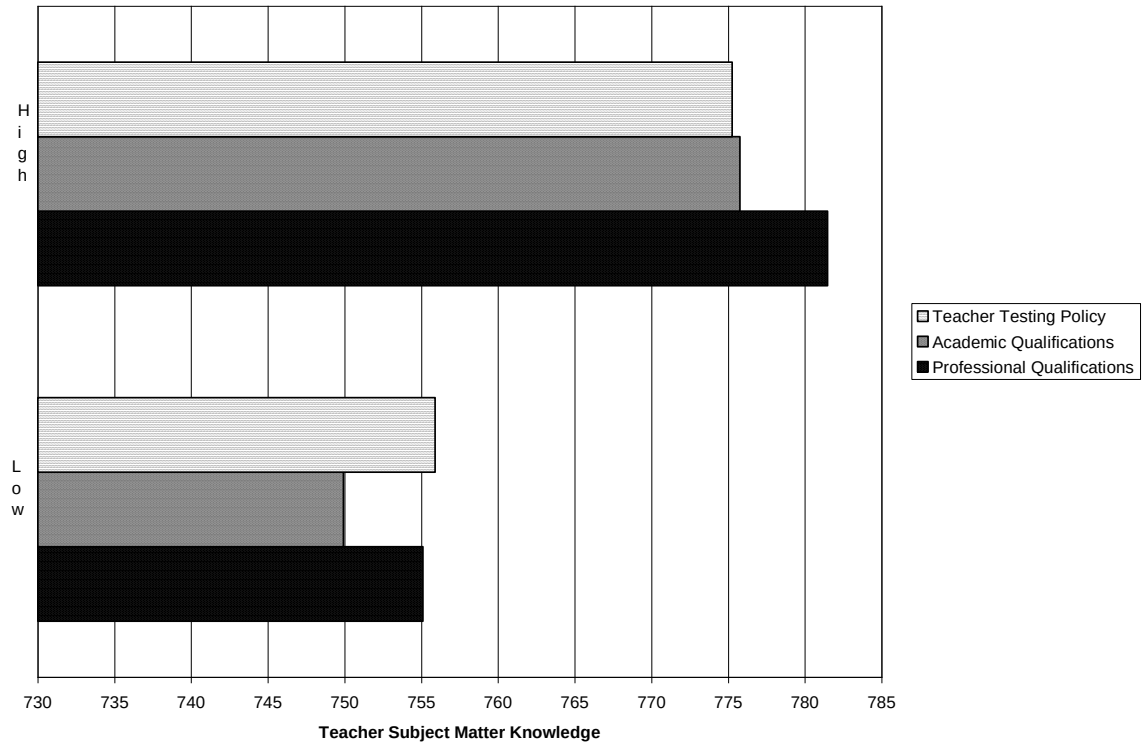


Variables Describing Schools

Earlier, we pointed out that primary school teachers require a junior certificate to be eligible for primary teacher training college. The completion of secondary school is increasingly encouraged for primary level instructors. For junior secondary school teachers, the prerequisite is a senior certificate. In both instances, the length of teacher training is three years. The Centre for Continuing Education at the University of Botswana also runs a four-year distance learning programme for primary school teachers. A unique feature of the SACMEQ survey is that it tested a sample of Standard 6 reading and mathematics teachers to assess how well they understood the subject matter that they

were teaching. Like the student test, each test was scaled to a SACMEQ mean of 500 and Standard Deviation of 100. In Figure 5 we compare teacher performance to some key background characteristics considered later in the multilevel analysis. We categorised primary school teachers with three or more years of professional training and who had completed secondary school as highly prepared and teachers with less than three years and without a senior certificate as less prepared. Teachers who tested their students at least once each week were placed in the 'high' testing category whereas those who assessed their students less regularly were grouped in the 'low' testing category. The difference in teacher performance in the test based on a teacher's professional and academic training is particularly wide (nearly 30 score points in each case). Unsurprisingly, schools with teachers who assed their students regularly tended to have a better grasp of the subject matter themselves.

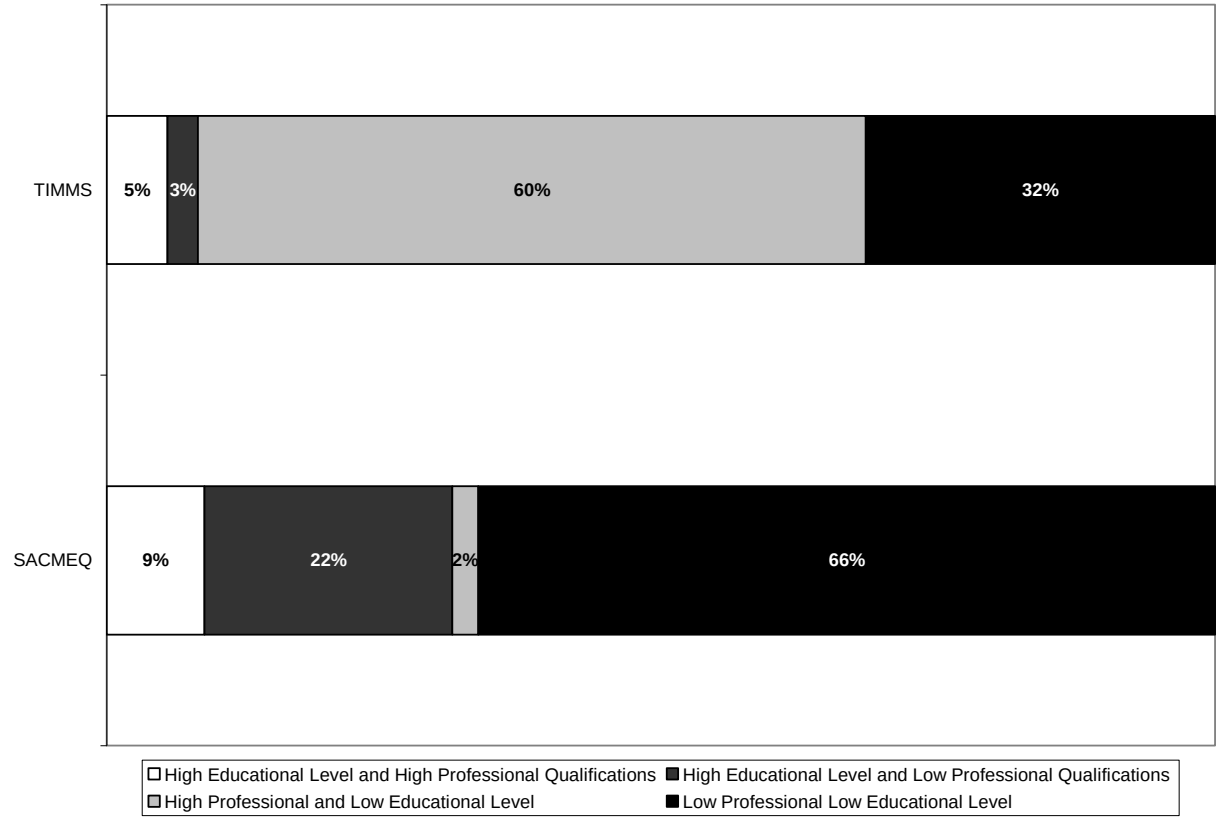
Figure 5: Teacher Background Characteristics and Subject Matter Knowledge: SACMEQ



In Figure 6, we combine teacher professional and academic qualifications to take a closer look at the level of preparation of primary and secondary school teachers. For the

TIMMS data, teachers were classified as having received a high level of academic training if they had a tertiary qualification. We also defined teachers with three or more years of teacher training experience as being well trained. The difference in teacher preparation for the junior and secondary levels is quite striking. At that stage the vast majority of primary school teachers (66 per cent) had less than three years of teacher training and had not completed secondary school. In contrast, most junior school teachers surveyed in 2003 had received adequate professional training (60 per cent) although only a handful (5 per cent) had exceeded official requirements by obtaining a tertiary qualification. Approximately one-fifth of primary school teachers had completed secondary school without fulfilling the necessary teacher training requirements. Less than 10 per cent of primary and junior secondary teachers had achieved exceptional levels of academic and professional preparation.

Figure 6: Teacher Professional and Academic Qualifications from the SACMEQ and TIMMS Surveys



5.2 Results of the Multilevel Analysis

Some of the descriptive evidence on students and schools has been fairly typical. Achievement advantages were seen among students with a better social and academic background and who possessed a more positive outlook about their studies. Less typical were the apparent discrepancies in teacher preparedness at the primary and secondary levels. The next section will show how student and school characteristics are related to mathematics achievement within a fully integrated multilevel model. This type of analysis is particularly well suited to testing the relationship between covariates that describe schools and outcome variables that identify students. Table 9a summarises the final multilevel model based on the SACMEQ data and Table 9b shows the results from analysing the TIMMS survey. The student variables are shown in bold characters. For SACMEQ, the student variables were socioeconomic status and grade repetition. For TIMMS, they consisted of socioeconomic status, student value and confidence in mathematics and teacher testing policies (see Appendix 1 for further details on variable construction).

There was a positive relationship between student socioeconomic status and mathematics achievement in both surveys, although the strength of the association was much stronger for SACMEQ than for TIMMS. Both SES measures contained information on household possessions and parental education levels. To improve comparison, we matched variables across datasets as closely as possible. However we also included additional information where it was clear that this would strengthen the analysis. The SACMEQ dataset provided useful details about the structural features of the student's home. This wealth dimension was added to the SACMEQ SES measure because it was more contextually specific than other conventional estimates (Buchmann 2000). It is very likely that it captured an important element of social status and made for a more robust measure in Botswana. Grade repetition was linked to lower performance at the primary school level. Students who had repeated a grade at least once scored nearly 50 points lower compared to their peers who had never repeated a grade (see Appendix 2 for a further note on repetition). At the junior secondary level there was a strong and steady association between measures of student self-efficacy and their actual mathematics

performance. Because the direction of causality was unspecified we cannot conclude whether this positive outlook is a cause or an effect of their high achievement.

In the TIMMS survey, questions about teacher testing were collected from students. Students who reported being tested regularly achieved better marks even after taking into account other student background characteristics. It could be argued that students who were tested regularly were more accustomed to the testing environment and were at an advantage when confronted with the survey testing instrument. There are several reasons why this is not likely to be a suitable explanation. First, the TIMMS testing instrument was varied in its structure. It posed questions about several dimensions of mathematics in a number of different ways. It is doubtful that each assessment approach was familiar to every student in the sample. Second, it is also doubtful that the testing approach used by individual teachers in the survey was the same even among teachers who assessed their students regularly. What these results suggest is that by evaluating student progress on a regular basis, a level of accountability is established both for the student and the teacher. It is easier for students to identify their standing relative to their peers and for teachers to determine the effectiveness of their instruction. It is interesting that the performance advantage of regular testing was fairly consistent across schools. There were no significant 'between-school' effects associated with regular assessment. Put slightly differently, the 30 point advantage in performance for students who were tested often related to an average for the entire sample and would not differ much depending on the school that a student attended.

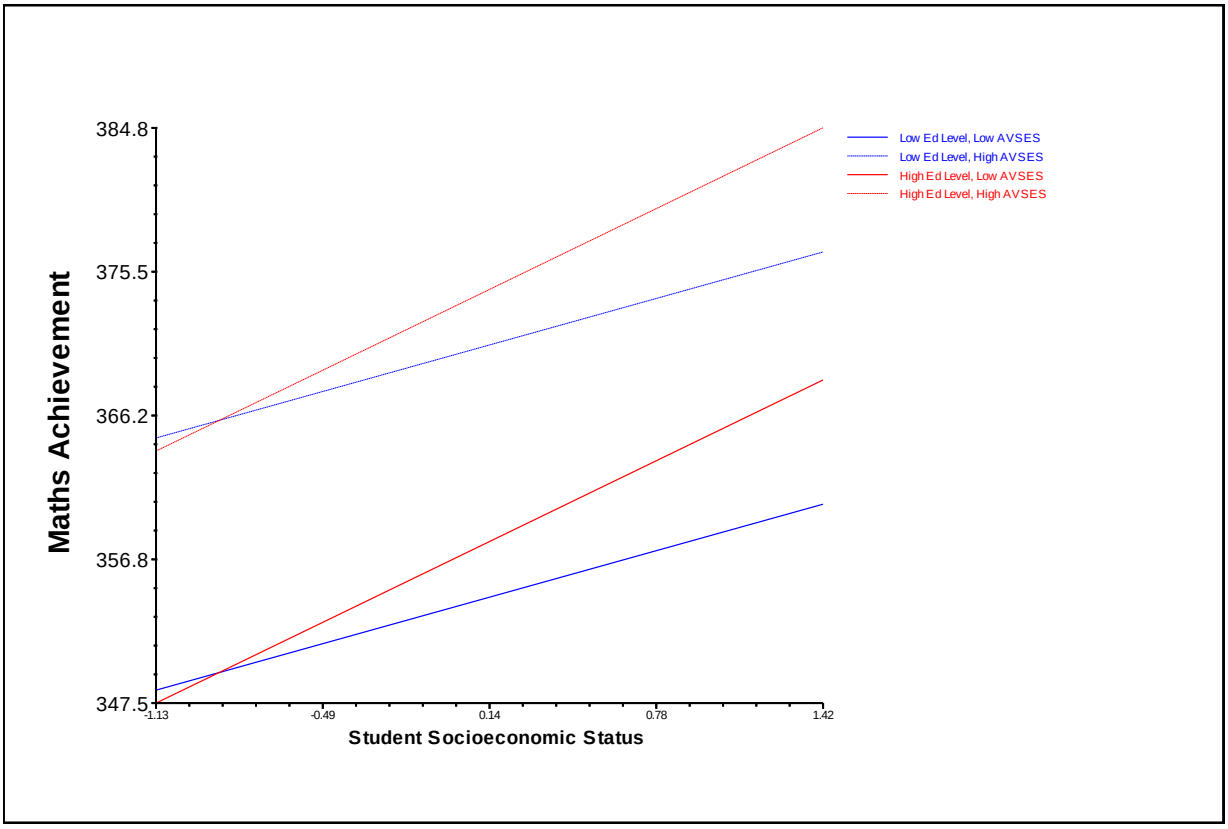
Turning to the school-level variables, the effect of the social class climate of the school (average socio-economic background) on average achievement was remarkably similar at the primary and junior secondary levels. There was a positive and significant relationship between the average social background of a school and mathematics performance. At the junior secondary level, even after controlling for individual values, a higher concentration of students who valued mathematics was associated with better test scores for the school. At the primary level, the percentage of repeaters in the school was positively related to achievement at a school, which would suggest that the presence of repeaters influenced the academic climate in a way that favoured general performance. Although the primary school examinations in Botswana are officially viewed as

diagnostic tools (95 per cent of students progress to secondary school), there is some competition to enter the best secondary schools. A primary school's reputation is also influenced by how well students perform in these national assessments. If this is the case then repetition could be encouraged both by parents and by schools. In terms of school structure, secondary schools situated in urban settings performed better than schools in remote areas.

The availability of school resources seemed to make a difference at the primary school level. 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. A 1SD increase in teacher subject matter knowledge was related to a 10 point increase in average school achievement. According to the TIMMS data, students benefit from being taught by teachers who had a tertiary qualification. Yet a tertiary qualification is not a requirement to train as a junior secondary school teacher in Botswana. Teachers with a degree are more likely to teach at senior secondary level. It is possible that these are expatriate teachers who trained elsewhere but we could not test this hypothesis with the available data.

A further result of interest in TIMMS was that teacher educational levels widened gaps in achievement between rich and poor students within the same school. Figure 7 illustrates this point more clearly for less affluent and more affluent schools. The top two lines represent high-SES schools and the bottom two lines represent low-SES schools. The more steeply sloping lines identify schools with teachers who are highly qualified and the less steep lines are for less qualified teachers. Because average achievement is higher in more affluent schools, the average value at the intercept is higher for the high-SES schools. However the effect of a teacher's educational level is identical in both groups of school. The visibly steeper slopes of the students taught by better qualified teachers imply that low-income students gained less from being taught by teachers with higher levels of academic training.

Figure 7: Teacher Educational Levels and Achievement for low and high SES schools: TIMMS



Some of the results on the organisation of learning are worth highlighting. Earlier studies in Botswana have shown that students are more likely to excel when they have regular sessions of instruction (Fuller, Hua, and Snyder 1994). Regular attendance was found to be important in Botswana primary schools. Schools with teachers who prioritised pupil learning above other professional goals also achieved better results. There was further evidence to support the benefits of teacher testing. Results from the SACMEQ survey indicated that regular testing raised average educational quality in a school while increasing equity among social groups. In Figure 8 the solid lines represent low-SES schools and the dashed lines represent high-SES schools. In schools where teacher testing is more frequent, students perform better (a higher intercept) and the gap between rich and poor students is less pronounced (flatter slopes).

Figure 8: Frequency of Testing and Achievement for low and high SES schools: TIMMS

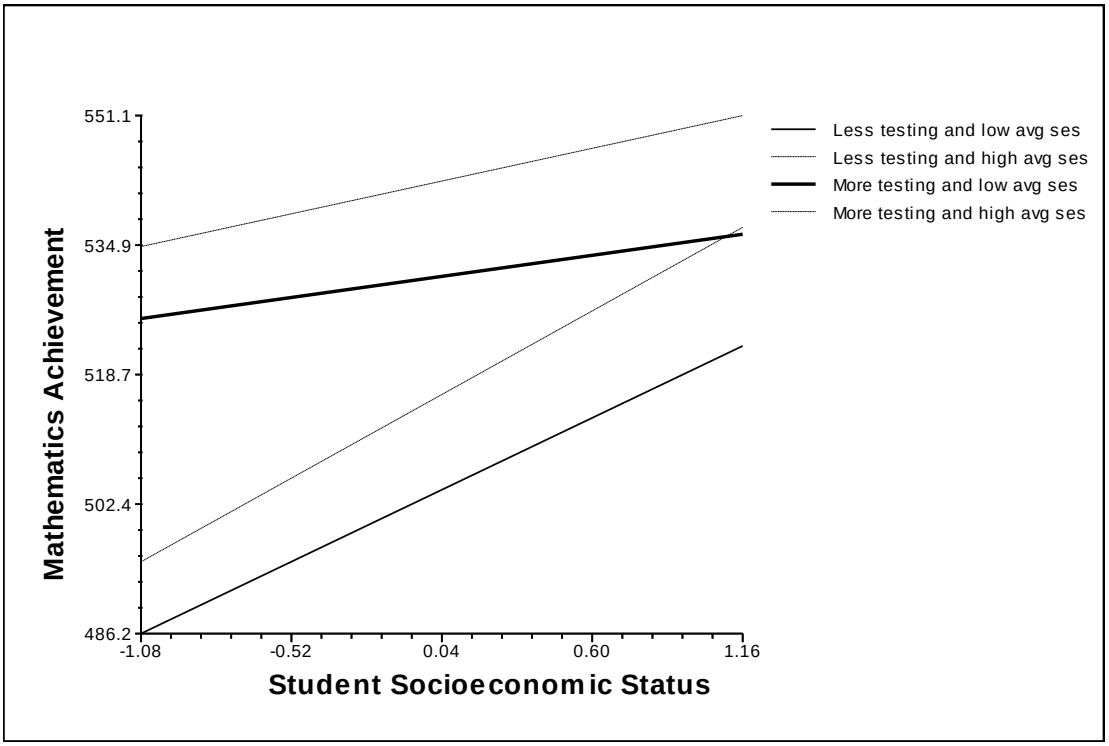


Table 9a: Final SACMEQ HLM Model for Mathematics Achievement Botswana

	Botswana
Intercept (Average Achievement)	509.60***
Measures of School Composition	
Average Social Background	10.75**
Percentage Repetition	6.95**
Measures of School Structure	
Urban School Location	5.71
Measures of School Resources	
Equipment	10.92***
Infrastructure	1.46
Teaching Resources	3.19
Teacher Professional Qualifications	-14.32
Teacher Educational Level	-3.33
Teacher Subject Knowledge	9.70***
Measures of School Organisation	
Student Attendance Problems	-5.52*
Pupil Progress Most Important Professional Motivation	15.62~
Teacher Testing Policy	27.26**
SES Achievement Gap (a)	17.24***
Measures of School Composition	
Average Social Background	2.41
Measures of School Instructional Organization	
Teacher Testing Policy	-11.01*
Repetition Achievement Gap (a)	-46.78***

Random Effects	**Variance Components**
Intercept, $\mu 0j$	593.12***
SES slope, $\mu 1j$	81.05
Level-1 error, rij ($\sigma 2$)	4668.43

~ p < .10; * p < .05; ** p < .01; *** p < .001

Table 9b: Final TIMMS HLM Model for Mathematics Achievement Botswana

	Botswana
Intercept (Average Achievement)	314.41***
Measures of School Composition	
Average Social Background	15.31***
Percentage Value Mathematics	4.57**
Percentage Confidence in Mathematics	-0.89
Percentage High Testing Mathematics	1.35
Measures of School Structure	
School Location	15.73~
Measures of School Resources	
Shortage of School Buildings	-6.89
Teacher Training	-3.40
Teacher Educational Level	5.04~
Measures of School Organisation	
Ability Grouping	-7.11~
Teacher testing policy	-4.72
SES Achievement Gap (a)	3.85~
Teacher Educational Level	4.19~
Average Social Background	0.79
Teacher testing policy	0.47
Student Value of Mathematics (a)	34.61***
Student Confidence in Mathematics (a)	26.77***
Teacher Testing in Mathematics (a)	21.29***

Random Effects	**Variance Components**
Intercept, $\mu 0j$	247.49***
SES slope, $\mu 1j$	5.97**
Level-1 error, rij ($\sigma 2$)	3574.89

~ p < .10; * p < .05; ** p < .01; *** p < .001

a. Only the SES achievement slope was allowed to vary between schools and was centered on each school's respective school mean.

6. Summary and Policy Recommendations

This paper has critically examined to what extent the teaching environment shapes educational opportunities in Botswana schools. Its central aim was to provide some policy direction into which teaching characteristics most effectively influenced the quality of learning in the country's primary and junior secondary schools. We began by introducing the subject area and providing an overview of its education system. Data were drawn from the 2000 SACMEQ survey of Standard 6 learners and the 2003 TIMMS survey of Form 1 students. We used a statistical approach that distinguished between how student background and school characteristics related to academic achievement. We also questioned whether teaching arrangements could potentially reverse social imbalances between students within the same school. The results demonstrated that there was an unmistakably positive relationship between student socioeconomic status and student self-concept on the one hand and how students performed in mathematics on the other. Whereas student achievement was lower for repeaters, there appeared to be positive effects related to repetition at the school level. Further research is necessary to understand why a climate with a high concentration of repeaters seemed to benefit performance and whether such advantages are enduring.

There was modest evidence to indicate that students attending well resourced schools were likely to perform better irrespective of their background. Equally, schools with higher concentrations of poverty (as measures by the average social background of students) achieved poorer results on average. Whereas some resource categories are within the domain of educational planners (such as the equipment supplied to schools), the provision of private resources are largely determined by parents and caregivers. There is another take on the relationship between private resources and student success worth mentioning. Recent work has begun to suggest that in countries where schooling is free and the social mix of students extensive, the manner in which students are treated in school will depend on their relative status in the community. Children from well connected families are likely to receive preferential treatment in schools. In other words, external social hierarchies are replicated within the school setting (Zuze 2008). In contrast, children of the poor may have a very different educational experience. Research elsewhere in Africa has documented cases of students being publicly humiliated and sent

home if their parents are unable to pay PTA contributions (Alubisia 2005). It could easily be argued that such situations are rare but the fact that the external environment has the potential to penetrate into schools needs to be recognised so that equal opportunities for learning are guaranteed.

One of the most striking findings of this research was that it established a clear association between teacher characteristics and student academic achievement. The relationship between teacher testing policies and educational quality remained strong and consistent at different levels of schooling. The effect of teacher testing remained even after taking into account teacher training and the resources available at the school. At the primary school level, teacher testing had the added advantage of improving the distribution of learning outcomes between rich and poor students. The implications of this trend are important. First, it should be realised that the success of student assessment goes beyond its frequency. To be effective, it needs to be identified as a tool for diagnosing gaps in knowledge. Therefore constructive feedback to students is critical. Second, great care must be taken to avoid some of the obvious pitfalls of existing standards based reforms. These policies have been criticised for placing too much emphasis on student performance when defining school success. Where teachers assume that their professional progress depends exclusively on their students' performance, there is a danger that disadvantaged students will be pressured to drop out or take less rigorous course loads (Diamond 2007; West and Pennell 2002). The financial dimension of monitoring and expanding teacher assessment should also be considered. Botswana already has a well developed teacher appraisal system (Monyatsi, Steyn, and Kamper 2006) but questions remain about how independently it operates. In her recent analysis of Standard 6 reading competency in Botswana, Masalila concluded that existing teaching strategies were insufficient for training students in higher order reading skills (Masaila 2008). She recommended that existing pre-service and in-service teacher training be revised to accommodate a more advanced level of instruction. Although this study has not focused on specific levels of student competency, it certainly contributes to the view that teaching methodologies that are correctly focused will yield lasting benefits for students in Botswana's schools.

Appendix 1: Description of Variables Used in the Multilevel Analysis

In this appendix, we present additional details about the variables that were used in the HLM analysis.

Variables from the SACMEQ Data File

Mathematics Achievement: A mathematics test score for Grade 6 students. The test consisted of 63 questions in total of which 27 questions covered numeric ability, 18 questions tested measurement and 18 questions assessed spatial ability. It was standardised to a SACMEQ mean of 500 and standard deviation of 100.

Socioeconomic Status: In constructing the ses index, three separate dimensions were created and then combined to represent the parental education level, household assets and the physical quality of the house. Parental education was a likert-type item coded from 1 (no school) to 6 (post-secondary and tertiary education). It was created by adding the individual values for mother's and father's education. The household assets variable was constructed by adding a series of dichotomous items that described the possessions found in a student's home. The items included in this dimension were: newspaper, magazine, radio, tv, vcr, cassette player, telephone, car, running water, electricity and a table. The physical quality of the house was based on four variables. Each variable had four possible responses. The variables were: source of lighting (ranging from fire to electricity), the wall material (ranging from 'not sealed' to 'cut stone or brick'), the floor material (ranging from 'not sealed' to 'carpet or tiles') and the roof material (ranging from 'not sealed' to 'tiles'). This dimension was derived by adding the four values together. We standardised the variable to a mean (M)=0 and a standard deviation (SD)=1.

Grade Repetition: A dummy-coded variable for whether a student had repeated a grade. It was coded '1' if the student had repeated a grade at least once and '0' otherwise.

Weighting variable: The student-level weight was proportional to the reciprocal of the probability of inclusion in the survey sample. The sampling weight adjusted for missing data and for differences in selection probabilities due to the multistage sampling design [PWEIGHT2].

Average Social Background: A school-level aggregate of Grade 6 student socioeconomic status. We standardised the variable within each country, mean (M)=0, standard deviation (SD)=1.

Percentage Repetition: A school-level aggregate of the prevalence of repetition among Grade 6 students. We standardised the variable within each country, mean (M)=0, standard deviation (SD)=1.

Urban School Location: A dummy-coded variable coded '1' for large town or city and '0' otherwise [SLOCAT].

School Equipment: A composite measure of school equipment consisted of information on the availability of the following school facilities: first aid kit, telephone, fax, typewriter, duplicator, radio, tape recorder, overhead projector, TV, VCR, photocopier and computer. We standardised the variable, mean (M)=0, standard deviation (SD)=1.

School Infrastructure: A composite measure of school physical resources consisted of information on the availability of the following school facilities: library, hall, staff room, office for the school head, store room, sports ground, garden, fence and cafeteria. We standardised the variable, mean (M)=0, standard deviation (SD)=1.

Teaching Resources: A composite measure of classroom resources consisted of information on the availability of the following school facilities: writing board, chalk, wall chart, cupboard, bookshelves, class library, teacher table and teacher chair. We standardised the variable, mean (M)=0, standard deviation (SD)=1.

Teacher Professional Qualifications: A dummy-coded variable based on a response from the teacher on their professional training. We coded the variable '1' for three or more years of professional training and '0' otherwise.

Teacher Academic Qualifications: A dummy-coded variable based on a response from the teacher on their academic training. We coded the variable '1' for teachers who had completed secondary school and '0' otherwise.

Teacher Academic Background: A mathematics test score for Grade 6 teachers. It was standardised to a SACMEQ mean of 500 and standard deviation of 100.

Student Attendance Problems: We constructed the variable based on the school head report of students arriving late at school, students' unjustified absence, students skipping classes and students dropping out of school. There were three possible response categories for each variable – never, sometimes and often. We aggregated and standardised a combination of the four variables, mean (M)=0, standard deviation (SD)=1. Higher values indicated higher levels of student attendance problems].

Pupil Progress Most Important Professional Motivation: We based the variable on information from the teacher about the most important element of job satisfaction. We coded the variable '1' if teachers indicated that seeing students learn was most important and '0' otherwise.

Teacher Testing Policy: A dummy variable for how frequently Grade 6 teachers administer a written test in mathematics. The variable was coded '1' if teachers indicated that they tested at least once each week and '0' otherwise.

Variables from the TIMMS Data File

Mathematics Achievement: A mathematics test score for Grade 8 students. As mentioned earlier, the TIMMS data provided 5 plausible values for each student. We used an iteration process that made use of all five plausible values in estimating achievement. It was standardised to a TIMMS mean of 500 and standard deviation of 100.

Socioeconomic Status: We constructed the TIMMS SES variable to match the SACMEQ measure as closely as possible. However, because there was no information on the structural features of the home in the TIMMS data file, we were restricted to two dimensions of student socioeconomic status: home possessions and parental educational levels. Home possessions included a calculator, a computer, a study desk, a dictionary as well as country specific items. The dichotomous items were added together. The parental education was a likert-type item coded from 1 (no school) to 8 (tertiary education). It was created by adding the individual values for mother's and father's education. The household assets variable was constructed by adding a series of dichotomous items that described the possessions found in a student's home. We standardised the variable, mean (M)=0, standard deviation (SD)=1.

Student Confidence in Mathematics: A dummy-coded variable based on student self-reporting of how confident they were in mathematics. It was coded '1' if the student was highly confident and '0' otherwise.

Student Value in Mathematics: A dummy-coded variable based on student self-reporting of how confidence they were in mathematics. It was coded '1' if the student was highly confident and '0' otherwise.

Teacher Testing in Mathematics: A dummy-coded variable based on student self-reporting of how often they have a test or quiz in mathematics. It was coded '1' if the student was tested in about half of the lesson time and '0' otherwise.

Weighting variable: The student-level weight was proportional to the reciprocal of the probability of inclusion in the survey sample. The sampling weight adjusted for missing data and for differences in selection probabilities due to the multistage sampling design [PWEIGHT2].

Average Social Background: A school-level aggregate of Grade 8 student socioeconomic status. We standardised the variable within each country, mean (M)=0, standard deviation (SD)=1.

Percentage Value Mathematics: A school-level aggregate of student value of mathematics. We standardised the variable within each country, mean (M)=0, standard deviation (SD)=1.

Percentage High Testing: A school-level aggregate of testing frequency based on student reporting. We standardised the variable within each country, mean (M)=0, standard deviation (SD)=1.

School Location: A dummy variable for size of school community. It was coded '1' for communities of at least 100,000 and '0' for smaller communities.

Shortage of School Buildings: A dummy variables based on a response from the school head as to whether there were any building shortages at the school. It was coded '1' where shortages were reported and '0' otherwise.

Teacher Training: A dummy variable for the number of years of teacher training. It was coded '1' for 3 or more years and '0' otherwise.

Teacher Educational Level: A dummy variable for the level of education attained by Grade 8 teachers in a school. It was coded as '1' if teachers had a first degree or higher and '0' otherwise.

Appendix 2: A Post Script on Repetition History

The issue of grade repetition is a complex one and extracting policy recommendations based on empirical evidence should be done with caution. It would seem that repetition should be discouraged unless there is indisputable proof that it is necessary. High rates of repetition compromise on efficiency and are costly to the entire education system. Widespread repetition practises can lead to large classes, with students who are on grade for their age forced to share their resources with students who are held back. Most of the evidence from this study of Botswana seemed consistent with existing claims that grade repetition is ineffective in improving educational quality. It is important to understand the context of repetition in Botswana. It is certainly possible that repetition represented an underlying dimension of schooling. If there is a pattern to repetition practices (for example if it occurs at specific grades rather than in a random manner), then perhaps it is actually representative of a *more efficient* schooling system where greater attention is given to academic preparedness. To test this hypothesis, the final HLM model was re-estimated with the sample of repeaters removed. The table below summarises the results of this alternate model. It is clear that there are only marginal differences in the results from this model and the full model presented in Table 9a above. Without additional information on the reasons for repetition and the actual grades where it occurs, it is difficult to draw firm conclusions about the relationship between repetition and educational quality.

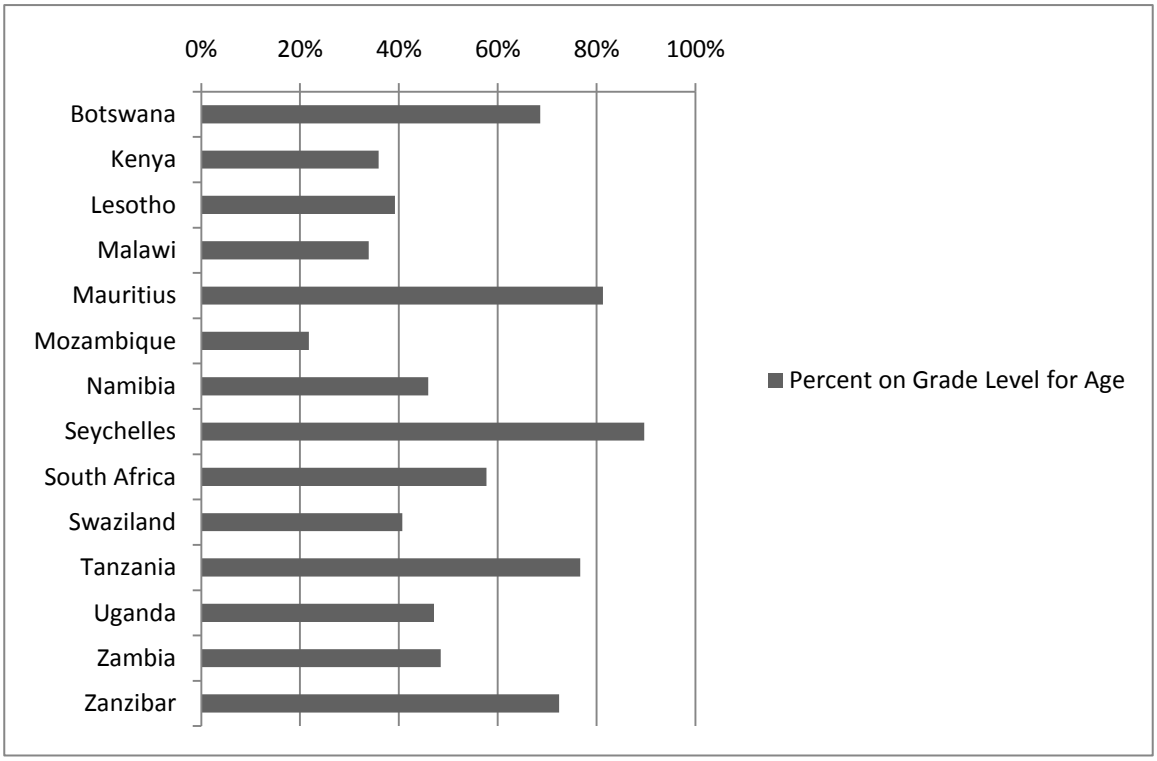
Final SACMEQ HLM Model with Repeaters Removed

	Botswana
Intercept (Average Achievement)	525.69***
Measures of School Composition	
Average Social Background	11.03**
Measures of School Structure	
Urban School Location	4.88
Measures of School Resources	
Equipment	9.45***
Infrastructure	3.62
Teaching Resources	-2.17
Teacher Professional Qualifications	-17.48~
Teacher Educational Level	-5.15
Teacher Subject Knowledge	10.77***
Measures of School Organisation	
Student Attendance Problems	-5.13~
Pupil Progress Most Important Professional Motivation	19.78*
Teacher Testing Policy	30.02**
SES Achievement Gap (a)	19.51***
Measures of School Composition	
Average Social Background	0.51
Measures of School Instructional Organization	
Teacher Testing Policy	-5.41
Repetition Achievement Gap (a)	-46.78***

Random Effects	**Variance Components**
Intercept, $\mu 0j$	547.16***
SES slope, $\mu 1j$	17.94
Level-1 error, rij ($\sigma 2$)	5113.66

Although the information is fairly limited, it is still possible to compare national and international repetition patterns to determine whether repetition rates in Botswana are unusually high. The figure below compares repetition rates for Botswana and other SACMEQ countries. From a regional perspective, the number of repeaters in Botswana was fairly low in 2000. It was more in line with countries that encouraged automatic promotion (such as Tanzania) than with countries where it was aggressively encouraged because of competitive school leaving examinations (such as Kenya).

Repetition Rates for SACMEQ Countries



The findings on grade repetition are inconclusive and because we could not separate academic and non-academic causes of repetition based on these data, our recommendations are tentative at best. Our findings suggest that: a) There is insufficient evidence to actively encourage an extension of the current repetition policy in Botswana. b) To offset the effect of repetition at early grades, attention should be given to school readiness and pre-school programmes. c) Because of the strong links between grade repetition and drop-out, further work is required on the effects of repetition on student attitudes to school.

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