A Cross-National Comparison of Primary School Children's Performance in Mathematics Using SACMEQ II Data for Botswana, Lesotho, and Swaziland

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Abstract

This paper reports about a cross-national comparison of sixth-grade pupils' performance in mathematics using the SACMEQ II data for Botswana, Lesotho, and Swaziland. Statistical analyses were done in order to explore the relationship between achievement in mathematics and factors such as gender, socio-economic status of pupils, location of the school, and access to mathematics textbooks. The results suggest, amongst other things, that Swazi sixth graders outperformed their Batswana and Basotho counterparts, with the latter showing lowest average scores in mathematics. Except for Lesotho, pupils from families with high socio-economic status outperformed their counterparts from low socio-economic status in Botswana and Swaziland. Furthermore, in all the three countries, pupils from the schools located in large cities out-performed their counterparts from small towns and rural areas; with the latter showing the lowest average scores in mathematics. Additionally, the socio-economic level of pupils tended to affect their achievement in mathematics differently depending on the location of the school. This paper examines some research and policy implications of the findings.

Introduction

The Jomtien World Conference on education for all held in Thailand in 1990 set the tone for the universalisation of access to basic education. In line with the sentiments expressed at Jomtien, the Dakar Framework for action (UNESCO, 2000) further defined the scope and content of basic education and set an important target in declaring, amongst other things, that by 2015 all children should have access to free, compulsory, and good quality education, especially in the areas of literacy and numeracy. In today's technology-oriented world, the need for all citizens to attain functional literacy in mathematics (numeracy) is well documented. For instance, the National Council of Teachers of Mathematics (NCTM) (2000) identifies four areas of use for mathematics: (a) mathematics for life which enables people to engage in such activities as purchasing, budgeting, or choosing insurance, health or retirement plans, (b) mathematics as a cultural heritage in which citizens can appreciate the beauty of mathematics, (c) mathematics for the workplace that enables people to apply problem solving skills in solving workplace problems, and (d) mathematics for the scientific and technical community which enables citizens to pursue mathematics and technology-oriented fields such as that of engineering. Correspondingly, Ross et al. (2004) describe the Southern African Consortium for Monitoring Educational Quality (SACMEQ)'s definition of mathematical literacy as the ability by an individual or a member of society to understand and apply mathematical procedures, and to make mathematical judgments.

Following the World Declaration on Education for All at Jomtien in 1990, a regional conference on Education for All for Sub-Saharan Africa held in Johannesburg, South Africa in December 1999, developed and adopted a framework for attaining education for all in Sub-Saharan Africa. More importantly, the framework identified a range of strategies for the improvement of the quality and relevance of education in the region. These included the need to:

(a) review and redesign curricular and teaching methods to make them more relevant to the psychological, educational, and socio-economic needs of the children, (b) define minimum and basic competencies for different levels of education, and (c) develop reliable education management and statistical information systems in order to improve analysis and decision-making.

In the aftermath of this regional conference, a number of countries in Sub-Saharan Africa, including Botswana, Lesotho, and Swaziland, took decisive steps towards the universalisation of access to basic education. Whereas Botswana had already abolished school fees as early as 1980, Lesotho introduced universal free primary education in January 2000. Swaziland is due to introduce Universal Primary Education (UPE) in 2006. There is a need, therefore, to document the extent to which countries in the region have moved towards the attainment of good quality education. One strategy to assess quality of the provision of education is to assess children's understanding of one of the key knowledge domains such as mathematical literacy. In agreeing with this line of thinking, English (2002) identifies the need to assess the extent to which students are currently developing key mathematical understandings, skills and processes as one of the priorities in international research in mathematics education. Accordingly, this paper compares the mathematics performance of 6^{th} grade children in Botswana, Lesotho, and Swaziland using the mathematics attainment data from SACMEQ II data archive.

Background

Commonly referred to as BOLESWA countries, Botswana, Lesotho, and Swaziland obtained independence from Britain in the mid-sixties ahead of

Zimbabwe and Namibia. Since then, the three countries have worked together in the various avenues of the education sector. For instance, the three shared a middle school examination (Junior Certificate [J. C.]) until 1979 when Botswana broke away, leaving Lesotho and Swaziland in the partnership. Nevertheless, the cultural and educational ties have continued to grow in other parts of the education sector. For instance, the BOLESWA (now called BOLESWANA after Namibia joined in 2003) International Research Symposium is one of the living symbols of the continuing cooperation that the three countries continue to enjoy in the field of education. Table 1 provides a summary of the key economic characteristics of each of the three countries.

[Insert Table 1]

As Table 1 indicates, Botswana's economy appears to be the strongest of the three. It can be argued that although the three countries have enjoyed and continue to enjoy different amounts of bilateral and multilateral aid since independence, it is reasonable to expect the education sector in Botswana to have benefited more from its strong economic base in terms of the infrastructure and the human and material resources available to the schools compared to Lesotho and Swaziland. Apart from the fact that primary education is of 7 years duration and that the medium of instruction for all subjects, excluding the vernacular, is English in these countries, each has had to grapple with the challenges of access, relevance, quality, and efficiency of primary education. More importantly, all have had to deal with the difficulties emanating from the fact that primary school teachers do not have a teaching major that is; they have to teach mathematics and 6 other school subjects. Despite these similarities, each country has had to deal with some context-specific challenges, some of which may be either cultural or historical in nature. For example, in the Lesotho context the fact that the provision of primary education is a joint responsibility between the government and the church remains an administrative challenge, especially as it pertains to equity in the deployment of qualified teachers (see Khati et al., 2001).

Research on Mathematics Education in Southern Africa

Research on the teaching and learning of school mathematics in Sub-Saharan Africa may be divided into two categories: (a) research on the teaching and learning of school mathematics in a specific context or country (e.g. Polaki, 1996; Polaki, 2004), and (b) cross-national comparisons of the teaching and learning of mathematics, and of children's performance in mathematics (e.g. Howie and Plomp, 2002). Some of the research on the teaching and learning of mathematics in the region has focused on the structure of teaching approaches (e.g. Sebatane et al., 1992; Polaki, 1996; Moeletsi & Malcolm, 2004; Mtetwa & Cleghorn, 2005). For example, in his work with secondary school mathematics teachers in Lesotho, Polaki (1996) found that a common approach to teaching mathematics was heavily teacher-centered, following the "teach-example-exercise" pattern. In practice, this entailed explaining how a certain mathematical procedure works (teach), demonstrating its use (example) and asking the students to do an exercise in the textbook (exercise). Similarly Mtetwa & Cleghorn observed that primary mathematics lessons in Zimbabwe took the form of a whole quick review followed by illustrative examples plus individual written work.

More often than not, the approach described in the foregoing paragraph is often focused on the development of low-order thinking skills such consolidation and practice of basic skills, with scant regard for high-order thinking skills such as problem solving and application of mathematical concepts. The reasons for this state of affairs are diverse and complex. For instance, Moeletsi & Malcolm (2004) found that whereas primary school teachers in Lesotho understood the importance of fostering high-order thinking skills in mathematics, they seldom focused on designing activities that nurture these skills as a result of the constraints imposed by lack of teaching resources, terminal assessment practices that call for low-order thinking skills, and their own habits, beliefs and pre-dispositions towards the teaching and learning of mathematics.

Some of the research on the teaching and learning of mathematics has focused on the impact of some environmental factors such as parental support and socio-economic backgrounds on students' performance in mathematics. For example, working in the Botswana context, Sabone et al. (2005) noted that the effectiveness of parental involvement and support for children's learning of primary school mathematics was dependent on family socio-economic background and level of educational attainment of parents. They further noted that parental support for children's learning of mathematics also differed between English and Setswana medium schools, with those attending Setswana medium schools getting little support compared to their counterparts in the English medium schools. This should not be surprising given that school fees at English medium schools are often higher compared to those required for non-English medium schools, and that only parents falling into the middle or higher levels of society are likely to send children to English medium schools.

Furthermore, the fact that children learn mathematics in language (second language) other than the vernacular has been found to affect their performance in mathematics (e.g. Nenty, 1999). Nenty observed that, amongst primary and secondary pupils in Lesotho, performance in English language was positively correlated with overall achievement in science and mathematics. In other words, good performance in English language was associated with good performance in science and mathematics; and poor performance in English was associated with poor performance in science and mathematics. This is partly rooted in the fact that those who have a reasonable degree of proficiency in English find it easy to read and interpret contextual problems. Further research is needed to fully understand factors that have given rise to these discrepancies.

Research on gender-equity in the provision of mathematics and science education has revealed some serious disparities, especially when it comes to access to the ideas of mathematics and science (e.g. Mulemwa, 2001). For instance, in his review of research on gender issues in science, mathematics, and technology education in Africa, Mulemwa concluded that boys seemed to be at par with girls in terms of enrollment rates at the primary school level. However, fewer girls appeared to be learning mathematics and science as they went up the education pyramid. This state of affairs is probably precipitated by the fact that more girls are either failing these subjects and/or opt for easier subjects as they go up the education pyramid.

Finally, very little research work in the Sub-Saharan region has been focused on the assessment of the teaching and learning of mathematics within and across nations. The results of the Third International Mathematics and Science Study (TIMMS) (Martin et al., 2000) revealed that South African 8th grade students performed far below most of the countries that participated in TIMMS. In a related study, Howie & Plomp (2002) noted that school factors that seemed to influence students' performance in mathematics were location of the school and students' first language. Howie and Plomp's study further showed that classroom factors that seemed to make a difference in students' mathematical performance were teacher commitment and attitude to work. In another study, Grayson et al. (2001) compared South African and Japanese mathematics teachers' confidence with the mathematics content and their perceptions about their professional responsibilities as teachers. Results showed that compared to their Japanese counterparts, South African teachers had (a) a very strong view of their role as knowledge providers, (b) a poor mathematics content knowledge, and (c) held a very narrow perception of their professional responsibilities as mathematics teachers.

Accordingly, this study extends research on the cross-national comparisons of students' performance in mathematics in Southern Africa by comparing the performance of 6th grade children from Botswana, Lesotho, and Swaziland using the SACMEQ II data archive. It is hoped that results generated from this study should constitute a basis for making some policy decisions that are designed to improve the teaching and learning of mathematics at the primary school level. Additionally, the results generated in this study should raise more questions and thus point to new directions to researching the teaching and learning of primary school mathematics.

Theoretical Approach

The data analyses and interpretation processes were guided by two major assumptions. The first is that national comparisons in education are inherently complex in nature and they do not make much sense when the objects being compared are too diverse in terms of their historical or cultural characteristics (Wang, 1998; Jan de Lange, 1997). The second is that the school system is constituted by three distinct components: (a) inputs, (b) processes, and (c) outputs (Shavelson, cited in Howie and Plomp, 2002). Inputs are policy-related factors that directly or indirectly impact on the processes of teaching. They include curriculum aims and objectives, human and material resources, and continuing professional development programs for teachers. The processes include what happens at the classroom level, including choice of approach to teaching, use of teaching resources, and the nature of classroom interactions. In this study the outputs were sixth-grade pupils' performance in mathematics. Thus inputs and processes interact with one another in shaping the nature of outputs which often take the form of performance in mathematics. Accordingly, it was assumed that by carefully studying the relationships among inputs, processes and outputs, it was possible to develop a basis for developing strategies targeted at improving pupils' mathematical literacy.

Purpose of the Study

In line with the theoretical approach described in the foregoing paragraph, this paper presents data to address the following research questions regarding the mathematics performance of sixth-grade children in the BOLESWA countries: (a) Are there differences in the performance of children in each of the three countries? (b) Are there gender differences in the performance of children within and across the three countries?, (c) Is there a relationship between location, socio-economic status and mathematics performance, and how does this compare across the three countries?, (d) What proportion of the variance in pupil's performance in mathematics is explained by school factors such as location, and how does this compare across the three countries?, (e) To what extent do pupils in each of the three countries have access to school mathematics textbooks?, and (f) What are the research and policy implications of the answers to each of these research questions?

Methodology

Population and Sample Design

In order to develop capacity building in monitoring the provision of good quality education in Sub-Saharan Africa, the Southern African Consortium for Monitoring Educational Quality (SACMEQ) was established. The first phase of the project (SACMEQ I) included ministries of education from 7 countries in the region: Kenya, Malawi, Mauritius, Namibia, Tanzania, Zambia and Zimbabwe). The SACMEQ II project was an expansion of the SACMEQ I project that included ministries of education from 8 more countries in the region (Botswana, Lesotho, Mozambique, Seychelles, South Africa, Swaziland, Uganda, and Tanzania (mainland). Both projects collected data on sixth grade children's numeracy and reading literacy as a way of monitoring the provision of good quality basic education in the region.

All pupils who were on the sixth-grade of the primary school at the time the data was collected, excluding those attending special education needs classes constituted the target population. Table 2 summarizes the number of pupils and schools associated with the planned and achieved samples.

[Insert Table 2]

The sampling procedure employed in SACMEQ II was a stratified multi-stage sampling, with educational administrative regions as domains of the study. In stratification, explicit and implicit strata were used with "Region" as the explicit stratification variable and "school size" as the implicit stratification variable. In particular, a two-stage sampling design was used to select a sample of pupils. The schools were selected by probability proportional to size (PPS) at the first stage and consequently they were primary sampling units (PSUs). Pupils within the selected schools were selected by simple random sampling (SRS) at the second stage, and hence were second stage sampling units (SSUs). Table 3 summarizes mathematics response rates, design effects and effective sample sizes across the three countries.

[Insert Table 3]

Data Sources

The mathematics component of the test that was given to sixth-grade pupils assessed three content domains, namely, number, measurement, and space-and-data. Whereas the number component included number operations, number line, square roots, rounding off, place value, significant figures, fractions, percentages, and ratios, the measurement component covered measurement concepts related to distance, length, area, capacity, money, and time. The space-and-data component of the test included items on geometrical properties of shapes, use of charts (bar, pie, line) and tables of data. Additionally, Pupils' Questionnaires and Head teachers' Questionnaires were used to general data pertaining to a number of variables, including pupil's socio-economic backgrounds, location of the school, and availability of textbooks.

Data Analysis

In addition to descriptive statistics showing summaries of pupils' performance across the three countries, analyses of variance (ANOVA) was used to explore (a) gender differences in mathematics performance, and (c) the relationship between location, socio-economic status and mathematics performance. More specifically, one-way and two-way classifications ANOVA were employed to establish the relationship between the mathematics performance and factors such as sex, location of the school, and socio-economic level of pupils. In particular, socio-economic level of pupils was represented by one factor, namely, index of possessions at the home of pupils. Additionally, pupils' access to mathematics textbooks was looked at as one of the critical factors that have a bearing on the processes that take place inside classrooms as students learn mathematics and on students' performance in mathematics.

Results

In the presentation of the major findings of the study, the two major themes pursued are: (a) pupils' performance in mathematics across the three countries, and (b) equity in the provision of mathematics across the three countries as reflected in the relationship between some environmental factors such as location and socio-economic levels on pupils' mathematical achievement. Accordingly, three sub-themes more closely examined are: (a) the relationship between gender and performance in mathematics, (b) the relationship between non-classroom factors such as school location and socio-economic status on pupils' achievement in mathematics, and (c) access to mathematics textbooks as one of the important factors that may be related to pupils' achievement in mathematics. The data analyses and interpretation processes are prefaced with an overview of pupils' mathematical performance across the three countries. Next, the relationships among the gender of the pupil, location of the school, socio-economic status of the pupil and achievement in mathematics are closely examined.

Mathematics Achievement in Botswana, Lesotho, and Swaziland

Table 4 summarizes sixth-grade pupils' mathematics achievement in Botswana, Lesotho and Swaziland. It shows the means and coefficients of variation (CVs) of grade six pupils' mathematics achievement by country, gender, socio-economic level, and location of the school.

[Insert Table 4]

As shown in Table 4, sixth-grade pupils in Swaziland outperformed their counterparts in Botswana and Lesotho, with those from Lesotho having the lowest mean compared to those from Botswana and Swaziland. Whereas pupils' mathematics achievement in Botswana had a relatively high coefficient of variation (16.0%), the one in Lesotho (13.5%) and in Swaziland (13.0%) had similar but lower coefficients of variation. Furthermore, the girls had a higher mean score compared to the boys in Botswana and Lesotho. Interestingly, this trend was reversed for Swaziland where the boys actually did better than girls. Additionally, pupils from families with high socio-economic levels did better than those from low socio-economic levels in Botswana and Swaziland. In contrast, pupils from families with high socio-economic levels were outperformed by those from families with low socio-economic levels in the Lesotho context. Finally, in Botswana, Lesotho, and Swaziland, pupils from large city schools outperformed their counterparts from the schools located in small towns and rural/isolated areas. It is noteworthy that, in all three countries, pupils from rural/isolated schools had the lowest mean scores compared to those from the schools located in small towns and large cities.

Gender Differences in Mathematics Achievement

As shown in Table 4, there was very little difference in the mean mathematics scores of boys and girls in Lesotho. Whereas the boys outperformed the girls in Swaziland, girls did better than boys in Botswana and Lesotho. Furthermore, the boys in Swaziland outperformed the girls in Botswana and

Lesotho. It is of interest to note that the girls in Botswana did better than their counterparts in Lesotho and Swaziland. Additionally, the measures of dispersion in the test scores for boys in Botswana and Lesotho were 16.1% and 13.8% respectively. These figures were slightly higher compared to those for girls in the same countries. In the case of Swaziland it is the girls who showed a slightly higher level of variation in scores (13.5%) compared to the boys (12.5%).

[Insert Figures 1.1, 1.2 and 1.3]

Prior to the use of an ANOVA to establish the nature of the relationship between the mathematics performance of sixth-grade pupils and gender, location, and socio-economic status, the distribution of mathematics test scores of pupils in each of the three countries was presented in the form of histograms (see Figures 1.1, 1.2, and 1.3) to determine whether it was statistically legitimate to conduct analysis of variance. These histograms illustrate that the distribution of mathematics test scores in each of the three countries was approximately normal, and therefore it was statistically legitimate to employ analysis of variance.

[Insert Table 5]

Interestingly, the one-factor ANOVA for the relationship between gender and pupils' mathematics achievement in Lesotho was not significant (see Table 5). This suggests that in Lesotho, boys were comparable to girls in their performance in the SACMEQ II mathematics achievement test. These results confirm the little difference in mathematics scores of boys and girls observed in Table 4. In contrast, the one-factor ANOVA for the relationship between mathematics achievement and gender in Botswana and Swaziland was statistically significant at the 1% and 5% levels respectively (see Table 5). This means that in Botswana and Swaziland the achievement of boys and girls in mathematics was found to be significantly different. In Botswana the girls significantly outperformed boys, and in Swaziland the boys significantly did better than girls. Estimated mean scores on the mathematics test by gender of the pupil are illustrated in Figures 1.4 and 1.5 for Botswana and Swaziland respectively.

[Insert Figures 1.4 and 1.5]

The estimated means for Lesotho were excluded because the mean mathematics scores for boys and girls were not significantly different. Figure 1.4 indicates that in Botswana the girls outperformed boys as it shows a higher mean test score for the girls. In contrast, the boys in Swaziland outperformed the girls. The two figures suggest that gender is one of the factors that could be used to explain differences in the mathematics performance of sixth-grade pupils in Botswana and Swaziland. However, it is important to note that the adjusted R-squared was lower than 5% for each of the two countries (see Table 5). In other words, gender accounted for less than 5% of the variance of pupil's scores in mathematics in Botswana and Swaziland, while in Lesotho, it did not account for variance in pupil's scores in the mathematics test. This suggests that there may be other factors that account for a greater portion of the variance in pupils' mathematics scores in Botswana, Lesotho, and Swaziland.

Location, Socio-Economic Status, and Pupils' Mathematics Achievement

The two-factor ANOVA was used to examine the relationship between mathematics achievement and environmental and socio-economic factors such as family socio-economic status of the pupil and school location (see Table 6).

[Insert Table 6]

The situations in Botswana, Lesotho, and Swaziland were similar in the sense that there were significant socio-economic level and school location effects, together with their interaction effects. In other words, family socio-economic level of the pupil, location of school attended, and the interaction of location and family socio-economic level had significant effect on the pupils' mathematics achievement. The interaction between the location and socio-economic level indicates that the effect of school location on mathematics achievement was different for pupils from families with different socio-economic levels. In other words, for Botswana, Lesotho, and Swaziland, school location influenced mathematics performance differently depending on the socio-economic level of the pupil.

The estimated mathematics mean scores of sixth-grade pupils by socio-economic level and school location are portrayed in Figures 1.6, 1.7 and 1.8 for Botswana, Lesotho and Swaziland respectively.

[Insert Figures 1.6, 1.7 and 1.8]

Figures 1.6 and 1.8 further illustrate that pupils from families with higher economic levels outperformed their counterparts from families with lower economic levels for all the three possible locations of the school in Botswana and

Swaziland. This is illustrated by the higher estimated mean scores of pupils from families with higher socio-economic levels. In Botswana and Lesotho pupils from families with lower socio-economic levels who attended the schools located in large cities outperformed their counterparts who attended the schools in small towns and isolated/rural areas (see Figures 1.6 and 1.7). Swaziland differed a little in respect of the means for pupils from families with lower socio-economic levels. The major difference was that in Swaziland the achievement of pupils from families with lower socio-economic levels was higher for the schools located in small towns than in large cities and isolated/rural areas. In the case of Botswana the achievement of pupils from families with lower socio-economic levels who attended schools in small towns was somewhat comparable to the performance of those who attended the schools located in the isolated/rural areas and in large cities. In the case of Lesotho, pupils from families with lower socio-economic levels who attended the schools located in large cities outperformed those who attended schools located in the isolated/rural areas and small towns. Those who attended the schools located in the isolated/rural areas showed relatively lower performance in mathematics for the three countries even when they came from families with higher economic levels. Interestingly, the Lesotho situation was rather inconsistent with the situations described for Botswana and Swaziland (see Figure 1.7). Although there was a significant interaction effect between location and socio-economic levels on pupils' achievement in mathematics, the Lesotho situation contrasted sharply with the situations for Botswana and Swaziland in the sense that pupils from families with lower socio-economic levels outperformed their counterparts from families with higher socio-economic levels irrespective of whether the school was located in a large city, small town or rural/isolated area.

The adjusted R-squared for the effects of socio-economic level, location and their interaction remained lower than 10% for Botswana, Lesotho, and Swaziland. This suggests that there may be other factors that could be used to explain the achievement of sixth-grade pupils in mathematics in each of the three countries. Accordingly, it was decided to explore pupils' access to mathematics textbooks as one of the classroom-related or teaching-related factors that could have had either a direct or indirect bearing on pupils' achievement in the mathematics.

Access to Mathematics Textbooks

Upon examining pupil's access to mathematics textbooks by country and across various locations some interesting disparities were noted. Table 7 summarizes pupils' access to mathematics textbooks by country, rural/isolated areas, small towns, and large cities. It is noteworthy that none of the three countries had more than 80% of pupils who reported to be having their own mathematics textbook. Only Botswana had the highest percentage (80%) of pupils who reported to be having a mathematics textbook of their own. Swaziland came second with 74.7% of pupils who reported having their own textbook, and Lesotho had the lowest number of pupils who reported having their own mathematics textbook (45.6%).

[Insert Table 7]

Additionally, Lesotho had the highest proportion of pupils who reported having no books (3.4 %). In this respect, Botswana (0.7%) and Swaziland (0.8%) had similar but lower percentages of pupils reporting not having a mathematics textbook of their own. These results suggest that compared to sixth-grade pupils in Botswana and Swaziland, those in Lesotho had less access to mathematics textbooks.

With regard to pupils' access to school mathematics textbooks by country and school location, the results appeared to be mixed (see Table 7). In Botswana pupils from rural/isolated schools had the lowest percentage (78.5%) of pupils who reported to be having a textbook of their own compared to those from the schools located in small towns (81.0%) and large cities (81.7%). The situation in Lesotho and Swaziland revealed a reversed trend. In Lesotho the number of pupils admitting to be having their own mathematics textbooks showed stability across the schools located in rural/isolated areas and small towns (48.1%), but dropped to the low of 33.3% in the schools located in large cities. Similarly, Swaziland showed the highest proportion (78.4%) of pupils who reported to be having their own textbooks in the schools located in rural/isolated areas. However, this proportion seemed to drop to 63.2% in small towns and 67.9% in large cities. These results suggests that in Lesotho and Swaziland, having one's own mathematics textbooks is taken more seriously in the schools located in isolated/rural areas compared to those located in the small towns and large cities. In Botswana, having one's own mathematics textbook appears to have received similar emphasis across the schools located in rural/isolated areas, small towns and large cities. It is also worth-noting that, for Lesotho, the number of pupils who admitted that they shared a book or that only the teacher owned the book was greater for the schools located in the rural/isolated areas compared to those located in small towns or large cities.

As for the accessibility and availability of books across different types of socio-economic backgrounds, Botswana and Lesotho had a common trend in that the proportions of sixth-grade pupils who reported having their own textbooks were slightly higher for pupils from families with higher socio-economic levels compared to those from families with lower socio-economic levels (see Table 8). In Swaziland, the proportions of students who reported having their own textbooks amongst children from families with lower socio-economic levels and higher socio-economic levels were similar.

[Insert Table 8]

Additionally, Lesotho had the highest proportion of pupils from families with lower socio-economic levels with no books (3.9%) compared to Botswana (0.9%) and Swaziland (1.1%). As for cases in which only the teacher had a mathematics text book Lesotho showed the highest proportion (7.8%) compared to Botswana (1.9%) and Swaziland (3.2%). Furthermore, Lesotho had the lowest proportion of pupils from families with lower socio-economic levels with own books (44.2%) compared to Botswana (78.6%) and Swaziland (74.9%). In addition, Lesotho had the lowest proportion of pupils from families with higher socio-economic levels having own books (47.6%) compared to Botswana (81.8%) and Swaziland (74.6%). The foregoing observations suggest that compared to those in Botswana and Swaziland, sixth-grade pupils from families with lower socio-economic levels in Lesotho had the least access to mathematics textbooks.

Discussion and Conclusions

The purpose of this paper was to explore differences in the performance of sixth-grade pupils' performance in mathematics using the SACMEQ II data archive for Botswana, Lesotho and Swaziland. With regard to overall performance in mathematics, sixth-grade pupils in Swaziland had the highest average. Botswana sixth-grade students had the second best average score, and their Lesotho counterparts had the lowest average score. While it may not be that useful to speculate on factors that might have precipitated these differences in mathematics achievement across the three countries at this stage, informal conversations with colleagues from Swaziland indicated that the primary education sector in Swaziland might have benefited from the fact that the distribution of schools enables easy and timely access by school inspectors. In contrast, reaching remote schools in the rural and mountainous regions of Lesotho is a great challenge. Likewise, given that Botswana is a vast country, it is probably a challenging task for school inspectors to access the schools in the remote areas within a short time.

Nevertheless, the results described in the foregoing paragraph call for more research work that focuses on a wider spectrum of factors that may have had a bearing on the mathematics attainment in primary school mathematics children in Botswana, Lesotho, and Swaziland. The units of analyses might include the content and scope of mathematics curriculum, quality of mathematics textbooks, and organization of the teaching and learning of mathematics. More importantly, a more focused documentation of what actually happens inside the mathematics classrooms across each of the three countries by way of the video-taping a sample of typical mathematics classrooms coupled with interviews with primary school mathematics teachers should go along way into enabling policy makers to make more informed decisions.

As for gender differences in mathematics achievement, the results revealed some noticeable discrepancies in Botswana and Swaziland, but not for Lesotho. Consistent with extant research on gender differences in mathematics and science achievement at the primary school level (e.g. Mulemwa, 2001), there were no significant gender differences in achievement in mathematics in Lesotho. These results suggest that Lesotho may be closer to attaining gender-equity at least in the provision of primary school mathematics. In Botswana the females outperformed their male counterparts in mathematics. In contrast, the males in Swaziland did better than their female counterparts. Although the reasons for these discrepancies are not obvious, the findings suggest that policy-makers in Botswana and Swaziland need to work towards the attainment of gender-equity in the provision of primary school mathematics education in their respective countries.

However, the fact that gender accounted for less than 10% of the variance in pupils' scores in mathematics suggests that there may be a host of other factors that may be used to explain differences in sixth-grade pupils' achievement in mathematics. In a sense, this provides credence to the call of use of a combination of quantitative and qualitative methods of documenting differences in the mathematics achievement of children in primary school mathematics. Accordingly, further research in this area might examine more closely the possible gender-bias in content of mathematics textbooks and other teaching materials, the way mathematics teachers interact with boys and girls in typical mathematics classrooms, and other factors that may directly or indirectly enable or inhibit access to key mathematics concepts across the three countries.

With regard to the relationship between location and achievement in mathematics, there were similar differences in mathematics achievement between pupils drawn from large cities, small towns, and rural areas in the Botswana, Lesotho and Swaziland. In all the three countries, pupils from large city schools had the highest mean score followed by children from small town schools. Children from rural schools had the lowest mean score. These findings suggest that there is no equity in the provision of primary school mathematics in schools located in the remote rural areas, small towns, and large cities across the three countries. Whereas the schools located in the remote rural areas were found to be the most disadvantaged, those from large cities were found to be the most advantaged. The policy implication of these findings is that each country should take decisive steps in the direction of improving the quality and equity in the provision of primary school mathematics in the schools located in the remote areas, small towns, and large cities. A starting point might be to conduct needs assessment studies, focusing more closely on such factors as accessibility of the school, number of teachers qualified to teach mathematics at the primary school level, teaching strategies, and availability of other teaching materials. This should serve as a basis for mapping out long-term strategies for attaining equity in the provision of mathematics achievement in the primary schools located in different contexts in each of the three countries

As for the relationship between socio-economic level and achievement in mathematics, pupils from families with high socio-economic status outperformed their counterparts from families with low socio-economic status in Botswana and Swaziland. In Lesotho, this trend was reversed. In fact, the two-factor analyses of variance showed significant effects for socio-economic status of the pupil and location of the school Botswana, Lesotho, and Swaziland. Moreover, significant interactions between the location and socio-economic status were recorded for Botswana, Lesotho, and Swaziland. These findings suggest that the provision of primary school mathematics is not equitable amongst pupils from high and low socio-economic status, with those from low socio-economic status being disadvantaged across the three countries. Given that our societies will always be differentiated in terms of socio-economic status of families, it may be wise for governments in each of the three countries to strengthen the equitable provision of resources at the school level, including distribution of qualified teachers and the monitoring of what actually happens inside the mathematics classrooms.

Upon examining access to mathematics textbooks as one of the factors that are related to what actually happens inside mathematics classrooms, it was found that compared to their counterparts from Botswana and Swaziland, pupils in Lesotho had less access to textbooks as evidenced by the low number of those who reported having their own mathematics textbooks. A policy implication for Lesotho is that a serious effort should be made to increase students' access to mathematics textbooks. Although the textbook situation appears to be promising in Botswana and Swaziland, it might be wise for all three countries to increase the availability of books and to investigate the way the textbooks are used once they are available. Additionally, it was observed that in Lesotho and Swaziland, the number of pupils who reported to have owned a mathematics textbook was greater among pupils from isolated and rural schools compared to those from small towns and large cities. This trend was reversed in Botswana. The challenge to policy makers then is to increase access to mathematics textbooks and to inculcate awareness of the importance of owning and adequately using a mathematics textbook.

This paper has identified factors that are related to pupils' achievement in Botswana, Lesotho, and Swaziland. These are (a) gender of the pupil, (b) location of the school, and (c) socio-economic level of the pupil. However, the results revealed that less than 10% of the variance in pupils' mathematics scores was explained by each of these factors and their interactions. These findings call for further research into other factors that may be related to achievement in mathematics at the primary school levels. It is worth-noting that this paper has not looked at other important factors such as teacher qualifications, frequency of home and feedback, teacher perceptions, teaching approaches, and the nature of classroom interactions. Further research work in this knowledge domain should examine all these factors in addition to carefully documenting the nature of classroom interactions. General policy implications include the need for Botswana, Lesotho, and Swaziland to continue to work towards the attainment of equity in the provision of primary school mathematics by increasing the material and human resources in the rural areas, small towns and large cities, and by ensuring that boys and girls have equal access to important mathematical ideas.

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APPENDICES

Table 1: Key Economic Indicators of the BOLESWA Countries

Country	Year of Independence	Population [2003 Estimate in millions U.S.$]	GDP [2003 Estimate in billions U.S. $]	Per Capita [2002 Estimate in U.S.$]	Real GDP Growth Rate [2003 % Estimate]	Real GDP Growth Rate [2004 % Projection]
Botswana	1968	1.6	5.1	2,980	3.7	3.6
Lesotho	1966	2.2	0.8	480	4.2	4.4
Swaziland	1966	1.1	1.2	1,220	1.5	1.6

Source: SADC Brief

Table 2: The Planned and Achieved Samples for Schools and Pupils in Botswana, Lesotho, and Swaziland

Country	**Schools**		**Pupils**	
	Planned	**Achieved**	**Planned**	**Achieved**
Botswana	170	170	3400	3322
Lesotho	180	177	3600	3155
Swaziland	170	168	3400	3139
Total	420	415	10400	9616

Table 3: Mathematics Response Rates, Design Effects, Effective Sample Sizes for BOLESWA Countries

School System	Response Schools	Rate Pupils	Design Effect	Effect Sample Size
Botswana	100	98	4.9	682
Lesotho	98	88	9.1	346
Swaziland	99	92	8.1	389

Table 4: Means and Coefficients of Variation for Mathematics Test Scores of Pupils in BOLESWA Countries by Categories

Category	Botswana		Lesotho		Swaziland	
	Mean	**C.V %**	**Mean**	**C.V %**	**Mean**	**C.V %**
	512.9	16.0	447.2	13.5	516.5	13.0
Gender						
Boys	508.2	16.1	445.7	13.8	518.9	12.5
Girls	517.4	15.4	448.3	13.3	514.3	13.5
Socio-Economic Level						
Low SES	498.9	14.7	448.6	13.2	511.3	12.1
High SES	529.8	16.3	444.9	13.9	522.2	13.8
School Location						
Isolated/Rural	500.5	15.3	436.8	13.0	510.9	12.3
Small town	517.4	16.1	456.7	12.0	528.3	11.7
Large city	530.6	16.4	482.2	14.3	531.1	15.9

Figure 1.1: Histogram for Mathematics Test Scores of Botswana Grade Six Pupils

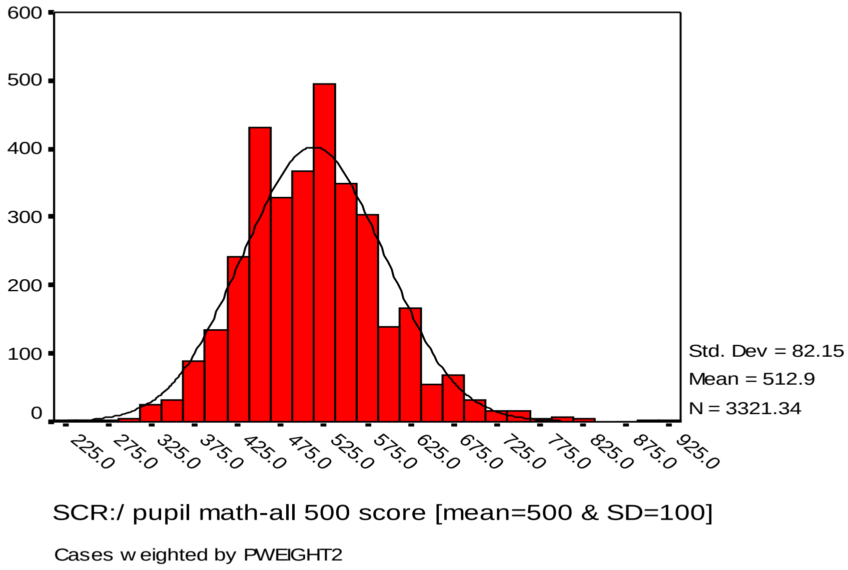

Figure 1.2: Histogram for Mathematics Test Scores of Lesotho Grade Six Pupils

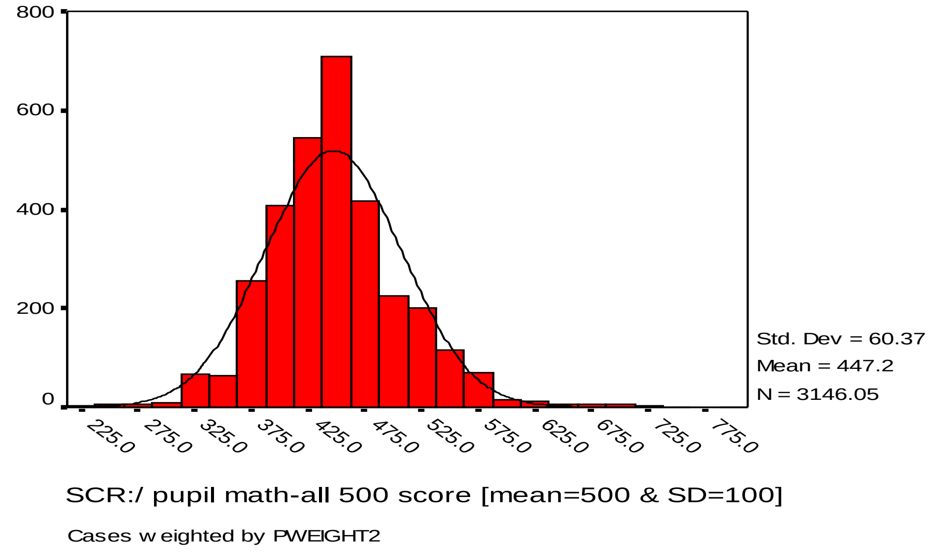

Figure 1.3: Histogram for Mathematics Test Scores of Swaziland Grade Six Pupil

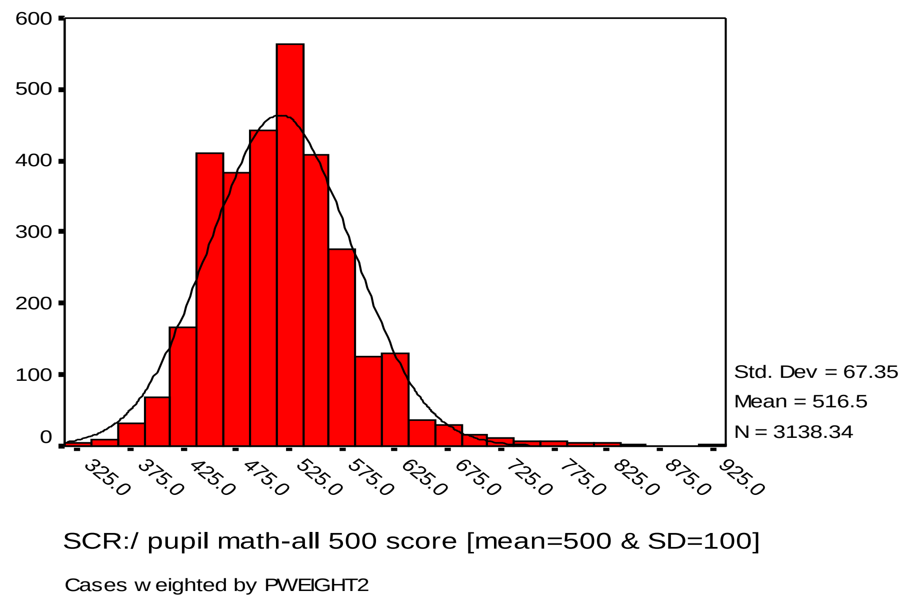

Table 5: One-factor ANOVA Table for Botswana, Lesotho and Swaziland

	Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Botswana						
Adjusted R	Intercept	879454356.1	1	8794543.1	129836.23	0.000
Square = 0.002	Gender	555836.485	1	555836.485	8.199	0.004
	Error	22583071.58	3334	6773.567		
	Total	902656719.4	3336			
LESOTHO						
Adjusted R	Intercept	616236234.4	1	616236234.4	167190.22	0.000
Square = 0.000	Gender	2121.326	1	2121.326	0.576	0.448
	Error	11485074.59	3116	3685.839		
	Total	635036536.6	3118			
SWAZILAND						
Adjusted R	Intercept	904714884	1	904714884	202929.6	0.000
Square = 0.001	Gender	19027.866	1	19027.866	4.268	0.039
	Error	15131368.1	3394	4458.270		
	Total	920546437	3396			

Figure1.4: Estimated Maths Score Means of Grade Six Pupils for Botswana by Gender

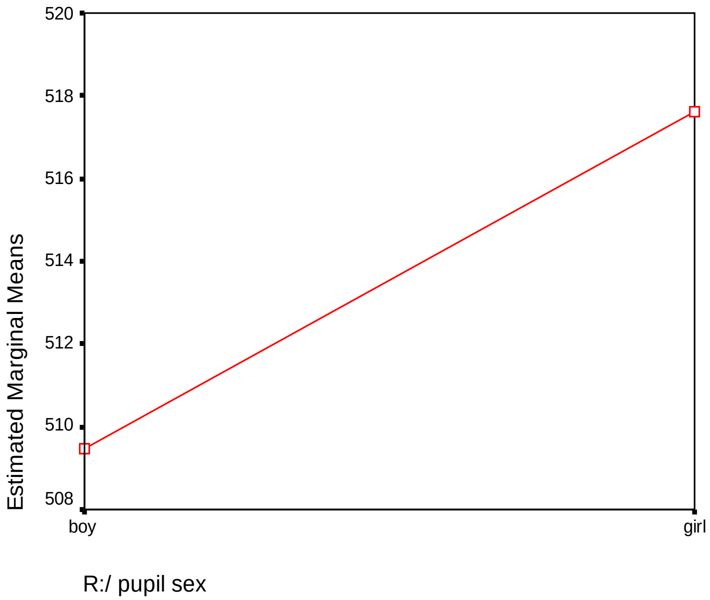

Figure 1.5: Estimated Maths Score Means of Grade Six Pupils for Swaziland by Gender

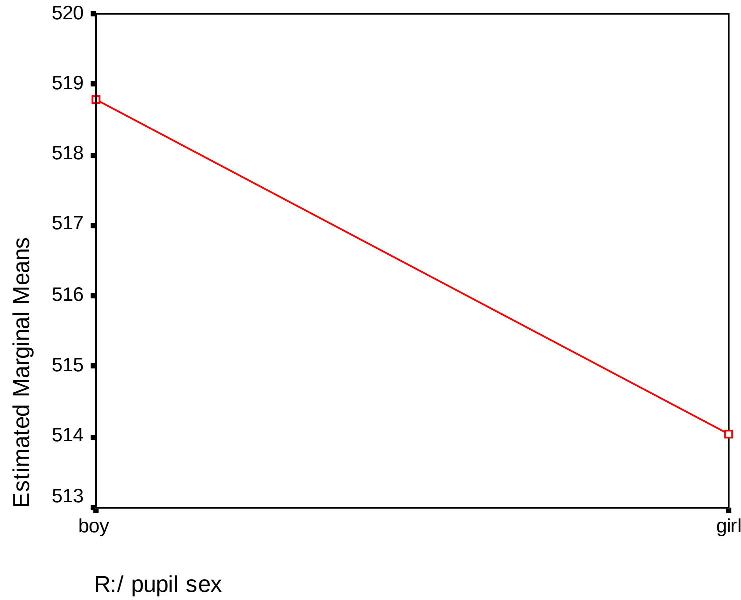

Table 6: Two-factor ANOVA Table for Botswana, Lesotho and Swaziland

Source		Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Botswana						
Adjusted R Square	Intercept	741682309.2	1	741682309.2	115785.68	0.000
= 0.056	Socio-Econ	671788.848	1	671788.848	104.874	0.000
	Location	296916.230	2	148458.115	23.176	0.000
	Socio-Eco* Location	200412.682	2	100206.341	15.643	0.000
	Error	21330808.6	3330	6405.648		
	Total	902656719.5	3336			
LESOTHO						
Adjusted R Square	Intercept	408533145.6	1	408533145.61	121002.08	0.000
= 0.084	Socio-Econ	164814.690	1	64814.690	48.816	0.000
	Location	934660.055	2	467330.027	138.417	0.000
	Socio-Eco* Location	60892.061	2	30446.030	9.018	0.000
	Error	10506886.32	3112	3376.249		
	Total	635036536.6	3118			
SWAZILAND						
Adjusted R Square	Intercept	435870333.3	1	435870333.34	99770.232	0.000
= 0.021	Socio-Econ	102313.499	1	102313.499	23.419	0.000
	Location	89108.169	2	44554.084	10.198	0.000
	Socio-Eco* Location	72037.235	2	36018.617	8.245	0.000
	Error	141810033.5392	3390	4368.741		
	Total	0546437.5	3396			

Figure1.6: Estimated Maths Score Means of Grade Six Pupils for Botswana by Two Categories

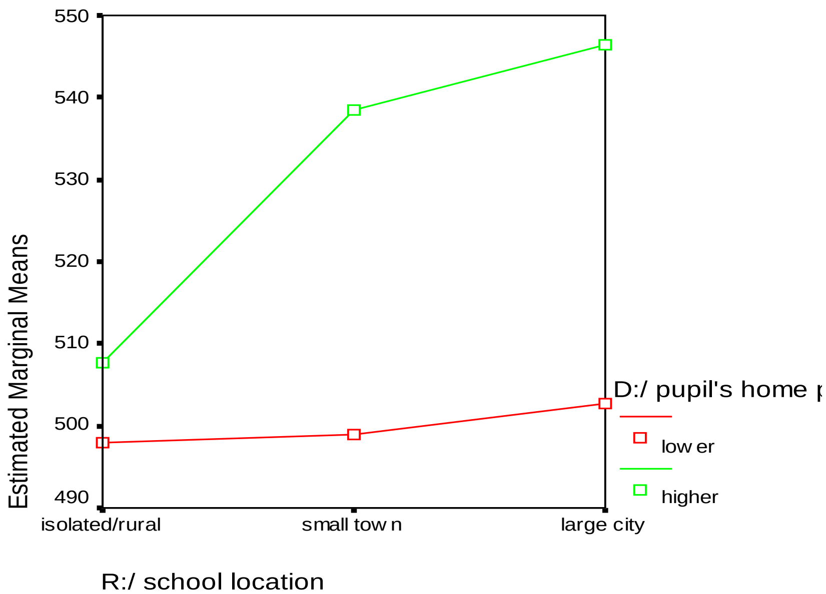

Figure 1.7: Estimated Maths Score Means of Grade Six Pupils for Lesotho by Two Categories

Figure 1.8: Estimated Maths Score Means of Grade Six Pupils for Swaziland by Two Categories

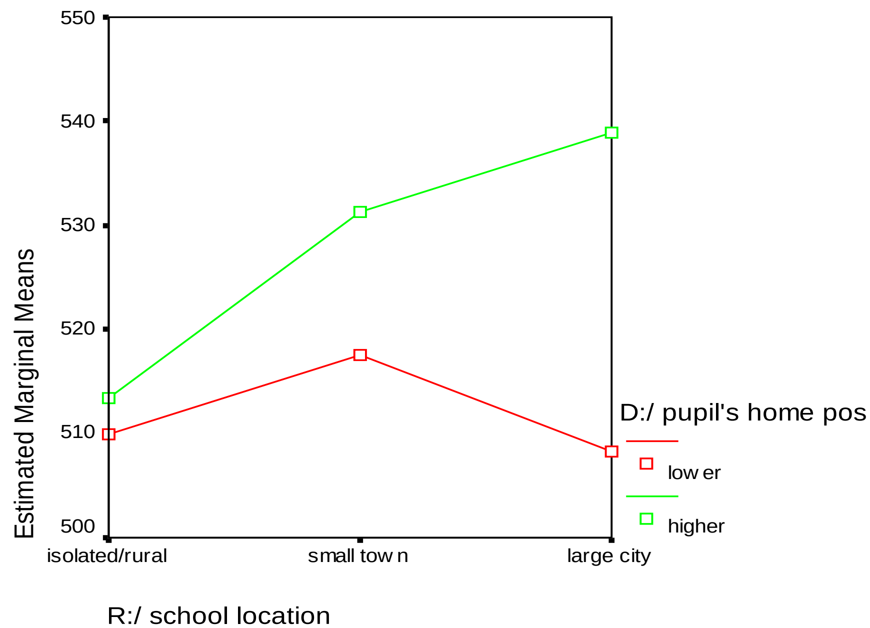

Table 7: Availability of Textbooks by School Location

Maths Textbooks Availability	School Location											
	Isolated/Rural Area			Small Town			Large City			Total		
Botswana	Pupils	Percent	S.E.	Pupils	Percent	S.E.	Pupils	Percent	S.E.	Pupils	Percent	S.E.
No textbooks	13	0.8	0.27	3	0.4	0.26	5	0.5	0.24	21	0.6	0.16
Only teacher has	33	2.2	0.51	3	0.4	0.22	9	0.9	0.40	45	1.4	0.28
Share with 2/more pupils	90	5.5	0.98	38	5.1	1.51	53	5.6	1.47	181	5.4	0.70
Share with one pupil	214	13.1	1.91	96	13.0	2.61	107	11.2	1.95	417	12.5	1.23
By myself	1281	78.5	2.62	598	81.0	4.18	778	81.7	2.82	2657	80.0	1.77
Total	**1631**	**100**		**738**	**100**		**952**	**100**		**3321**	**100**	
Lesotho	Pupils	Percent	S.E.	Pupils	Percent	S.E.	Pupils	Percent	S.E.	Pupils	Percent	S.E.
No textbooks	72	3.5	1.42	14	2.0	0.64	22	5.3	2.03	108	3.4	0.97
Only teacher has	150	7.3	1.17	59	8.6	2.04	42	10.0	2.54	251	8.0	0.89
Share with 2/more pupils	407	19.9	2.30	145	21.0	2.83	158	37.8	9.90	710	22.5	2.15
Share with one pupil	434	21.2	2.65	158	22.9	4.05	57	13.6	3.59	649	20.6	1.98
By myself	985	48.1	3.69	314	48.1	4.86	139	33.3	8.95	1438	45.6	2.89
Total	**985**	**100**		**690**	**100**		**418**	**100**		**3156**	**100**	
Swaziland	Pupils	Percent	S.E.	Pupils	Percent	S.E.	Pupils	Percent	S.E.	Pupils	Percent	S.E.
No textbooks	20	0.9	0.35	2	0.5	0.51	4	0.8	0.50	26	0.8	0.27
Only teacher has	32	1.4	0.49	14	8.0	1.33	33	10.1	5.93	99	3.1	1.07
Share with 2/more pupils	83	3.8	2.03	6	1.5	0.74	20	3.8	1.50	109	3.5	1.45
Share with one pupil	342	15.5	3.14	125	31.3	8.52	92	17.5	5.57	559	17.8	2.59
By myself	1736	78.4	4.33	252	63.2	8.20	358	67.9	7.91	2346	74.7	3.40
Total	**2213**	**100**		**399**	**100**		**527**	**100**		**3139**	**100**	

Table 8: Availability of Textbooks by Socio-Economic Level

Maths Textbooks Availability	Socio-Economic Level								
	Lower Socio-Economic Level			Higher Socio-Economic Level			Total		
Botswana	Pupils	Percent	S. E.	Pupils	Percent	S. E.	Pupils	Percent	S. E.
No textbooks	16	0.9	0.26	5	0.3	0.16	21	0.6	0.16
Only teacher has	34	1.9	0.43	11	0.7	0.31	45	1.4	0.28
Share with 2 or more pupils	108	5.9	0.81	73	4.9	0.97	181	5.5	0.71
Share with one pupil	231	12.7	1.54	185	12.3	1.35	416	12.5	1.23
By myself	1429	78.6	2.16	1228	81.8	2.01	2657	80.0	1.77
Total	**1818**	**100**		**1502**	**100**		**3320**	**100**	
Lesotho	Pupils	Percent	S. E.	Pupils	Percent	S. E.	Pupils	Percent	S. E.
No textbooks	76	3.9	1.48	32	2.6	0.68	108	3.4	0.97
Only teacher has	151	7.8	1.00	99	8.2	1.23	250	7.9	0.89
Share with 2 or more pupils	428	22.0	2.11	283	23.4	3.88	711	22.5	2.15
Share with one pupil	429	22.1	2.29	220	18.2	2.52	649	20.6	1.98
By myself	860	44.2	3.16	577	47.6	3.99	1437	45.6	2.89
Total	**1944**	**100**		**1211**	**100**		**3155**	**100**	
Swaziland	Pupils	Percent	S. E.	Pupils	Percent	S. E.	Pupils	Percent	S. E.
No textbooks	18	1.1	0.44	8	0.5	0.23	26	0.8	0.27
Only teacher has	53	3.2	1.09	46	3.1	1.18	99	3.2	1.07
Share with 2 or more pupils	76	4.7	2.14	33	2.2	0.75	109	3.5	1.45
Share with one pupil	264	16.1	2.75	295	19.6	3.11	559	17.8	2.59
By myself	1224	74.9	4.08	1122	74.6	3.44	2346	74.7	3.40
Total	**1635**	**100**		**1504**	**100**		**3139**	**100**	