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Grade Six Learners' Performance in Mathematics: A Comparison between Rwanda, Botswana and South Africa

Dr. Jean Francois Maniraho[1]* and Dr. Leon R. Mugabo[2]
[1]College of Education, University of Rwanda

[2]African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science University of Rwanda,

*Corresponding author: **jmaniraho2@gmail.com**

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Abstract: *While South Africa and Botswana have participated in several international or regional studies on learners' mathematical competencies, no such studies have been conducted in, or have included, Rwanda. This study reports on Grade 6 learner mathematics test results from 20 Rwandan schools, selected using stratified sampling, and compares these to the results from similar studies conducted in Botswana and two provinces of South Africa. The results indicate that the learners across the four sets of data are performing similarly on many topics, but that the Rwandan learners perform much better on numeracy questions using the four basic operations as was hypothetically suggested. Some reasons for these differences are considered and discussed in the light of current curriculum movements in Rwanda.*

Keywords: Mathematics, learning, test scores, Rwanda, Botswana, South Africa, Grade 6, international, comparison

1. Introduction

South Africa, Botswana and Rwanda share the common challenge of low learner performance in mathematics compared to the performance in other subjects and when compared with other SACMEQ countries (Maree, Aldous, Hattingh, Swanepoel, &van der Linde, 2006; MINEDUC, 2006;Schollar, 2008). Despite the different studies in mathematics education agreeing that the failure rate in schools remains unacceptably high (Maree, Pretorius, & Eiselen, 2003; Maree &Steyn, 2003), in Rwanda there are no studies we found on the relationship between teaching and learning in mathematics for primary schools, and there are few cross-border comparisons(Uworwabayeho, 2009).This paper is a contribution to the gap observed in comparative studies on mathematics education, including Rwanda, particularly, as it has been observed that it is not possible to compare Rwanda's mathematics performance with other countries since there is little, if any, participation of Rwandan students in regional or international mathematics tests(Uworwabayeho, 2009).

The study on which this paper reports is part of a larger study on teaching and learning in Rwandan Grade 6 classrooms. To enable comparisons with South Africa, the study replicated a study previously conducted in two of South Africa's provinces and in Botswana (Ally & Christiansen, 2013; Aungamuthu & Christiansen, 2013; Carnoy, Chisholm & Chilisa, 2012; Noubouth, forthcoming; Ramdhany, 2010). In this paper, we simply compare the learner performance on the pre-test, and a hypothesis that Rwandan learners perform better on Mathematics basics. Later papers will engage the approaches to teaching in Rwanda compared to South Africa.

2. Review of Related Literature and Studies

Trends in International Mathematics and Science Study (TIMSS) is the best known international comparative study on students' mathematics achievements, particularly in Africa. South Africa had a chance to participate in TIMSS from 1995; they also took part in the 1999 and 2011 studies, the latter for grade nine. Botswana

participated in TIMSS 2007, in which 59 different countries around the world took part, and in TIMSS 2011 with Grade 9 learners. Apart from their participation in TIMSS, both South Africa and Botswana are members of The Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ), which is an additional chance for both countries to assess their educational standards compared to other countries in the region. Apart from the Rwandan data, in the African context, we considered the data from Botswana and the ones of two provinces of South Africa.

The situation is different for Rwanda, which has not taken part in any studies of this nature. In their report (Moloi & Chetty, 2011a) found that 79% of learners in all the SACMEQ countries had basic learning materials and that majority of Grade 6 teachers had appropriate qualifications and had attended continuing professional development courses with satisfactory regularity (Moloi & Chetty, 2011b). For Botswana, this was similar regarding basic learning materials, but around a third of the learners did not have individual mathematics textbooks (Monyaku & Mmereki, 2011). In South Africa, 82% of the learners had all the three basic learning materials required for classroom learning activities, which is a good figure compared to the one indicated above for the overall SACMEQ countries, and 36% of the learners had individual mathematics textbooks (Moloi & Chetty, 2011a).The situation in Rwanda is not known, but of the 20 classes observed by the first author, the situation was different depending on the location of the schools. Learners in urban schools were well equipped compared to those in rural areas. On the one hand, eight out of ten schools in urban areas learners had the basic learning materials like mathematics note books, mathematics exercise books and mathematics kits containing geometrical tools, which could help them to participate in classroom activities. On the other hand, the situation was vastly different in rural schools where no single school out of ten visited with learners equipped with all basic materials, apart from mathematics note books, a considerable number of learners did not have mathematics exercise books and had to combine notes and exercises. Furthermore, mathematics textbooks were often shared between two or three learners (Maniraho, 2017).

The performance of South African Grade 9learners in the 2011 TIMSS study was very poor (mean score of 3.8) compared to that of other participating countries like Hong Kong with a mean score of 7.8 (Mullis, Martin, Foy, & Arora, 2012), and the same was found for the Grade 6learners in the SACMEQ studies(Howie, 2004). Even though Botswana was ranked just above South Africa in both the TIMSS 2011 study and in SACMEQIII (Spaull, 2011), the performance of Grade 6learners in these two countries is similar in terms of overall test scores. This was also confirmed in a recent medium scale study in the North-West province of South Africa and Botswana (Carnoy et al., 2012).

The low mathematics achievement in South Africa has been explored in several studies, both large scale correlational studies and smaller scale studies for an overview, see (Hoadley, 2012). The variation between schools is greater in South Africa than elsewhere (Case & Deaton, 1999) due to the Apartheid legacy which still carries over. This is strongly linked to socio-economic factors in the home situation, which is a stronger factor in the performance of South African learners than it is in the other SACMEQ countries (van der Berg et al., 2011).

Within the school and more related to the teaching, important achievement factors appear to be: discipline/classroom management, feedback, frequency of homework, feeling secure/safe in the school, curriculum coverage, and presence of questions of high cognitive demand, while teaching methods are less significant (Ally, 2012; Ramdhany, 2010; Reeves, 2005; Spaull, 2011; van der Berg et al., 2011). It seems the availability of textbooks matters to reading, but not to mathematics (Spaull, 2011). In a study of Grade 6 teaching and learning in KwaZulu-Natal overseen by the second author, 15% of the differences in learner performance was accounted for by the teacher being present and the language of instruction (Christiansen & Aungamuthu, 2012). Looking at the results from SACMEQ III,Moloi andChetty (2011b) posit that the important factors were teaching practice, teacher development, the use of resources and the (un)availability of teachers who are able to expose learners to extensive applications and high order questions involving both concrete and abstract problem solving skills. As posited by Ally & Christiansen, (2013), the latter teaching approaches were rare in the KwaZulu-Natal study that it was not possible to assess if they would indeed make a difference, but this does highlight the lack of opportunities to develop mathematical proficiencies for the majority of South African learners.

3. Research Methodology

This part explains the methodology used to guide the study.

3.1 Method

The study is a correlational study in design, where the difference in learner performance at the beginning and end of Grade 6 is taken to reflect a learning gain, which is then correlated with various background factors. In line with the studies which informed the Rwandan Grade 6 project, a range of data was collected. This included a learner test at the onset of Grade 6 (pre-test), repeated at the end (post-test), learner questionnaire, teacher questionnaire, teacher test combining content knowledge and pedagogical content knowledge, and video recordings of one or two lessons with each teacher. In addition, a sample of learners' books was inspected close to the end of the year in order to determine the curriculum coverage.

3.2 Sample

Through random stratified sampling, the first author selected 20 primary schools across seven districts in Rwanda. In this paper, we compare the learner test results to those of two provinces in South African samples among which 39 KwaZulu-Natal schools(Christiansen & Aungamuthu, 2012), 58 North-West province schools and 58 schools in Botswana(Carnoy et al., 2012).In all the cases, some stratification to reflect rural and urban areas was used to ensure spread on socio-economic contexts of the school.

3.3 Data Collection

In the part of the study we are concerned with here; data was collected through a test, consisting of 40 multiple choice questions. The test was the same in the Rwandan study as in the two studies we compare our results to, except for adjustments in names and other contextual information. These questions covered some Grade 6 content but mostly content from lower grades, in particular Grade 5, relevant to all three countries considered here. Incorrect answers had been designed to reflect common misconceptions. The learners did the tests individually and without calculators.

The tests were administered in English, which is not the mother tongue of most of the learners in the study, though it is the language of instruction. In South Africa, mother tongue has been found to be strongly linked to the learners' performance (Christiansen & Aungamuthu, 2012), but it cannot be concluded that the learners would have performed better if the test had been in English, as shown by Zumaand Dempster (2008). In Rwanda, the language of instruction changed in 2008 (Gahigi, 2008), from French to English, and is highly likely that this may have disadvantaged the learners.

Ethical issues included the guarantee of anonymity of participants, as obtained via informed consent of learners' parents, consent from the Ministry of Education and consent from the teachers and principals of the schools.

3.4 Data analysis

The Rwandan learners' responses to each question in the pre-test were entered into a spreadsheet, and the relative frequency of correct answers determined. The same had already been done with the KwaZulu-Natal data, with which we compare below. We do not have access to the data for the North-West province and Botswana, but estimated these from the results presented in the report on that study (Carnoy et al., 2012). After our initial comparison of the results, the learners' responses were classified according to the primary mathematics content domains (number, geometry, and so forth).

4. Results and Discussion

The mean test score in Rwandan sample of 713 learners is 40.31with a standard deviation of 9.9 whereas the mean test score for the South African KwaZulu-Natal sample of 1276 learners was29.6witha standard deviation of 13.3. For the Botswana sample of 1750 learners, the mean was 33.6, and for the North West sample of 3800 learners, the mean was 28.6 (Carnoy et al., 2012, p. 87). These overall results confirm previous findings, with Botswana and South Africa Grade 6 learners performing very similarly, though Botswana learners doing slightly better than South African learners. We can now add to this the information that the Rwandan learners do somewhat better overall.

What is interesting is to consider the variations within these performances. For this purpose, we looked at the learner performance in the four data sets across content domains (Figure 1). Again, note that the individual item results for the North-West province and Botswana are estimated from the results sections in the report on the study. The graph shows a good correspondence between the performance of the learners in the two South African provinces, some differences between learners South Africa and Botswana on a few items, and a larger number of differences between learners in the Rwandan compared to the other three studies.

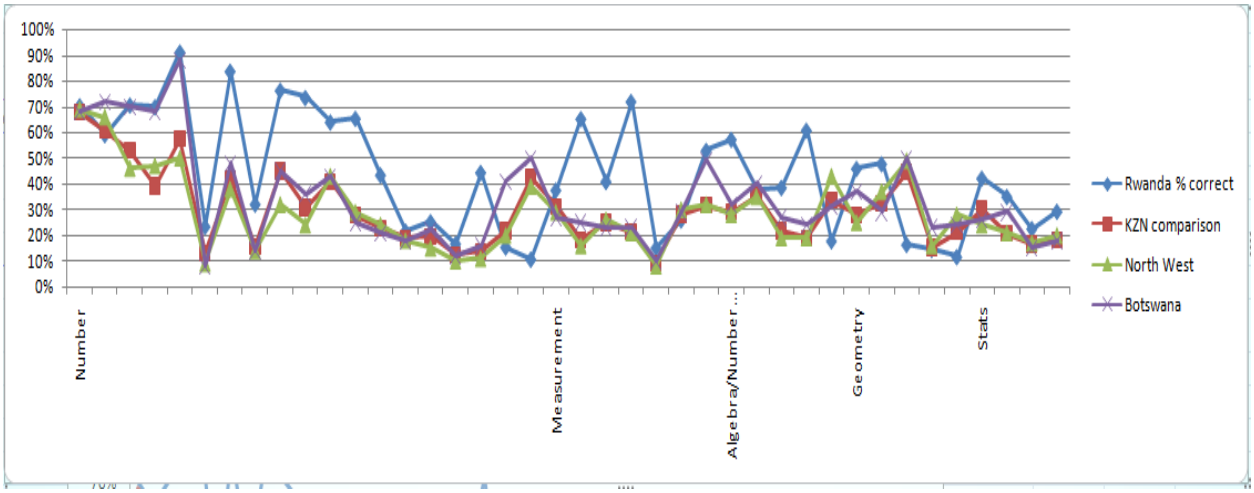

Figure 1: Mean test scores for each test item, grouped according to content domain.

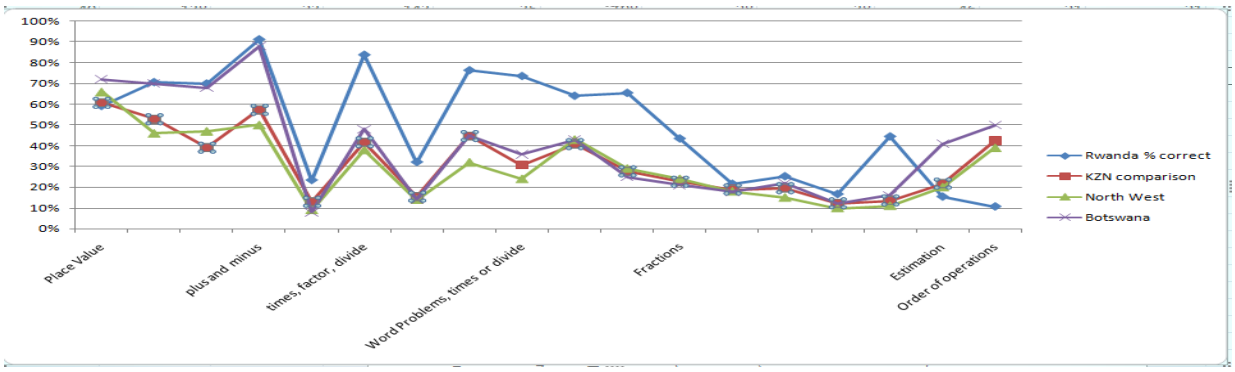

Figure 2: Learner performance on items within 'number'.

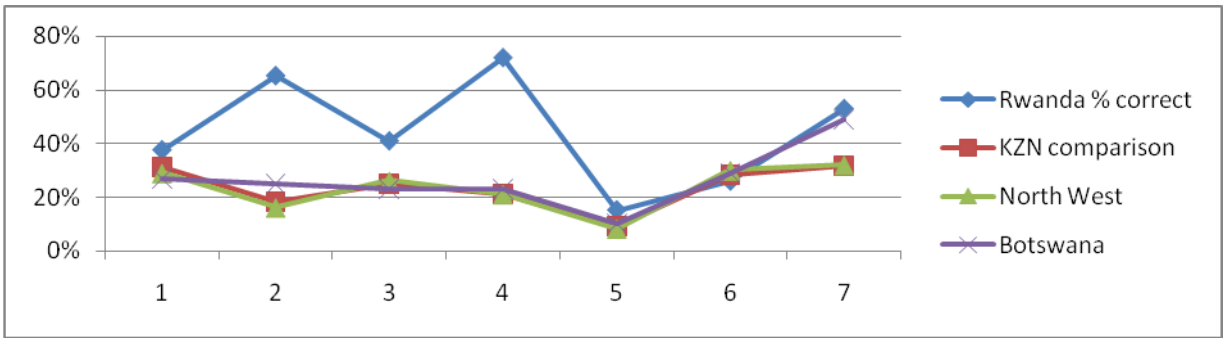

Figure 3: The learner performance on items in 'measurement'

The Rwandan learners fared worse than their counterparts in four of the questions: in a question concerning order of operations, a question on reading off a grid, a question on recognizing circles amongst other geometrical shapes, and a question on recognizing a two-dimensional side-representation of a three-dimensional figure. The differences in favor of the Rwandan learners showed up mostly in the content domains number and measurement clearly observed by a further breaking down of the learner tests results within number (Figure 2).

There was only one question on estimation and one on order of operations, and generally the learners performed badly on these questions, with the Rwandan learners faring very badly on the order of operation question. Learners across the four studies appear to battle with fractions, except that the Rwandan learners did much better on a word sum on finding a fraction of a whole number and a word sum of finding a multiple of a half.

The Rwandan learners also did much better on word problems involving multiplication or division of whole number with above 78% score marks, as well as on other basic operations though the learners across all four cohorts did not perform well on a question asking them to find differences between values read off a table and list the largest difference (two-step problem). Both the Rwandan and the Botswana learners did better on place value questions, as well as the only other question involving simple addition and subtraction. Taking into consideration to the variation in learner performance on the seven items classified as measurement (Figure 3), the learners across the four cohorts did not do well on a multi-step problem of finding an area of a shape in a grid where the unit square was not one, while a question on determining time in a different time zone and a question of ordering volumes according to size appear to have been equally difficult for all the learners.

However, the Rwandan and Botswana learners did much better on a question of recognizing the correct unit for measuring mass, and the Rwandan learners did the best on the remaining three questions on converting units and deciding on the most appropriate unit for a particular task.

As we scrutinized these results to determine a pattern, we thought it looked like the Rwandan students did better on the 'basics'. We therefore coded the questions in the test according to the levels of 'numeracy' developed from the SACMEQ studies (Hungi et al., 2010). Only one of the questions was on level one, one question was on level seven, and there were no questions on level eight. For the questions on levels two-six, we calculated the mean of the scores (Figure 4). As can be seen, Botswana and Rwandan learners scored somewhat higher than the South African learners on the level two questions, and the Rwandan learners score better than the other three cohorts on level three questions. After that, the groups are rather comparable. This supports our hypothesis about Rwandan learners performing better on 'the basics', with level two being emergent numeracy and level three being basic numeracy, characterized as "Translates verbal information presented in a sentence, simple graph or table using one arithmetic operation in several repeated steps. Translates graphical information into fractions. Interprets place value of whole numbers up to thousands. Interprets simple common everyday units of measurement." (Hungi et al., 2010, p. 8).

Of course, this needs to be explored further, in terms of differences in curriculum, teaching approach, and other factors.

5. Conclusions and Recommendations

Looking across the areas where the Rwandan learners perform much better than their counterparts in the other three cohorts, it appears that they have a stronger foundation in the most basic numeracy. While we need to compare Grade 6 mathematics teaching and curricula across the countries to be able to interrogate the reasons for this, we do note the differences in the colonial histories of the countries. Whereas Botswana and South Africa have strong historical links with the British Empire, Rwanda was under the influence of the Germans and then the more strongly colonial impact from Belgium, which established French as the language of instruction and developed a number of educational initiatives. Thus, it is likely that the education systems in these countries still reflect their very different histories and the cultural-educational differences in attitudes to education (Broadfoot, 1999), including value-laden choices about what is considered best practice or what the purpose of education is (Boltanski & Thévenot, 2000; Christiansen, forthcoming).

This makes it particularly interesting to have established this current snapshot of teaching and learning in Rwanda, as the change to a new English medium only curriculum due to the increased links to the East African community may or may not lead to changes in the influences on the regulative and instructional discourses of Rwandan schooling. Only time will show.

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