COMPARING STUDENTS' AND TEACHERS' STATISTICAL KNOWLEDGE IN BOTSWANA AND SOUTH AFRICA: SOME PRELIMINARY RESULTS

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The development of instruments used to compare students' and teachers' knowledge in South Africa and Botswana countries is examined. The hypothesis is that there are differences in the performance of statistics items within students as well as within teachers given that one country has a higher allocation of resources for education and higher level of teacher preparation in statistics. A total of 140 sixth grade teachers were surveyed from randomly selected schools in border providences of both countries. Data has been collected and analysis of the items is in progress. Preliminary results from South Africa show low levels of performance.

INTRODUCTION

Despite widespread acceptance of the notion that improving student performance may have a high economic and social payoff, policy analysts in all countries have surprisingly little empirical data on which to base educational strategies for raising achievement. In South Africa this question is all the more pressing. South African students score at low levels in mathematics and language tests even when compared with students in other African countries (Van der Berg & Louw, 2006). Further, the South African government's own evaluations of ten years of democracy show little improvement in educational outcomes despite significant policy changes (DoE, 2006). While some reasons for this poor performance may be evident, and there is widespread agreement that the main challenge in South Africa is the quality of education, there is little *empirical analysis* that helps policy makers understand the reasons for the low level of student performance in South African schools or how to improve it (Carnoy et al., 2008).

To explain why South African schools do not perform at the same level as other African countries, the Human Sciences Research Council of South Africa in partnership with a consortium of universities, and researchers at the School of Education at Stanford University and the Mathematics Department at Texas State University engaged in an empirical study that compares randomly selected primary schools from Botswana and the Northwest province of South Africa. The study focuses on the role that teacher skills and practice play in students' learning within the socioeconomic and administrative conditions in those schools. The research team collected multiple measures concerning student, teacher, and school data.

The development of the student and teacher instruments was guided by national curricula documents (Botswana Upper Primary Maths Syllabus and South Africa National Curriculum Statements Grades R-9 Mathematics). The student test and teacher questionnaire included all areas of mathematics at the Grade 6 level (11-12 years old), in this paper we focus on the items measuring knowledge of statistics or data handling.

TEACHERS AND TEACHER PREPARATION

Botswana

In the early 2000s, Botswana had almost 13,000 primary school teachers for about 330,000 primary school students, or a pupil-teacher ratio of 26:1. The number of primary teachers and the number of primary students has remained almost unchanged since 1998. Although the proportion of "untrained" teachers fluctuates from year to year, the percentage in the early 2000s hovered around 10 percent. Primary teaching is largely a female profession, with around 80 percent of female teachers. Close to 95 percent of the teachers are Batswana (native to the region of Botswana and western South Africa), but the percent of non-Batswana is rising slowly, from 4 percent in 1995 to 6 percent in 2004.

All teachers at the primary level are required to have a Diploma in Primary Education. The Diploma in Primary Education is a three-year long program. In order to be eligible for the program, and thereby eligible for primary teacher training, all applicants are required to have completed the

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Cambridge Overseas School Certificate (COSC) Ordinary Level or the Botswana General Certificate of Secondary Education (BGCSE). The Diploma is offered at four Colleges of Education (Francistown, Lobatse, Serowe and Tlokweng). These colleges are under direct control of the government and graduate about 400 teachers annually; more than 60 percent of them are women. Those training for the Diploma in Primary Education are required to take all the subjects in the Primary School Curriculum. They are also required to select an area of specialization from one of the following combinations: (1) Mathematics and Science, (2) English and Setswana, (3) Social Studies and Religious Education, (4) Practical Subjects (any two from Agriculture, Arts and Crafts, Home Economics, Music and Physical Education). It is inferred that the area of Mathematics and Science includes the study of statistics as well. Those who teach without the Diploma in Primary Education are required to undergo an upgrading course to acquire it. This course is offered by the Centre for Continuing Education at the University of Botswana in the form of a distance-learning program. Teachers who hold the Primary Teaching Certificate (PTC) are required to undergo the above upgrading course as the PTC has been phased out. As of 2002, approximately 9.3 percent of primary school teachers remained untrained, and by 2004, this proportion had dropped to 7.5 percent.

In addition to the above programs, the University of Botswana produces graduate teachers in Bachelor of Education with specialization in primary teaching and in secondary teaching. It also offers a one-year Post Graduate Diploma in Education for graduates in general degree programs (Bachelor of Science and Bachelor of Arts) who qualify to teach in secondary schools. Secondary school teachers who have at least six years of teaching experience are eligible to be recruited by the Colleges of Education for their staff development programs.

South Africa

In 2006, there were more than 380,000 practicing teachers in the South African public school system including teachers paid by government and school governing bodies. Of these, 27,226 were primary school teachers. The majority of primary school teachers in South Africa are African, female, and below 41 years of age. The pool of qualified mathematics teachers in primary schools is small. Many qualified mathematics teachers are not teaching their subject, and there are large numbers teaching mathematics who are not qualified to do so. The reasons for this are obscure as a system exists to match supply with demand in the Post Provisioning Model and the administration of "excess" and "vacancy" lists.

Qualified primary school teachers are on the whole diploma-holders. In 2004, more than 50,000 teachers were considered under-qualified. Only 5,4% of teachers in 2005 had been prepared in their teacher training for the new Curriculum. The majority had been trained in teacher education colleges whose quality varied enormously. Those established in the former bantustans and homelands, now South Africa's rural areas, were notorious for their limited curricula and the link between this curriculum and the expectations of the roles of teachers under apartheid as docile and low-skilled. The system of college-based teacher education was brought to an end in 1999 on the grounds that it provided poor quality education and was not cost-effective. Teacher education for both primary and secondary teachers is now conducted at universities, but the quality of this has not yet been evaluated. The point remains that most teachers in the system were trained under a period of time that did not equip them to teach the curriculum. There have been consistent complaints that the short-term training provided for teachers to enable them to teach the new curriculum has not been effective. There is also evidence of a decline in enrolments in initial teacher education programmes since 1999. Numbers are low especially for those in the under 25 age group. The decline here has been greatest for African women. This new curriculum expects not only that teachers draw on professional knowledge to teach to a higher level than before, but that they also employ student-centered teaching methods, a variety of forms of assessment and embrace values consistent with the new Constitution.

METHODS

After a large pilot data collection in the Gauteng's province of South Africa (Carnoy et al., 2008), 70 schools from each country (140 total) were selected randomly from the two Ministries of Education data files. In Botswana the sample included Gaborone, Kgatleng, Lobatse, South East,

and Southern schools. In South Africa the sample included schools from the Northwest towns such as Mafikeng, Mmabatho, Buhrmansdrif, Loporung, Zeerust, and Lerato schools. These territories were selected because they are located in the border of both countries and they have similar cultural background. Students were given a mathematics test at the beginning and at the end of the school year. Their teachers were visited in the middle and at the end of the school year. In the first visit, teachers answered a questionnaire and taught a lesson that was videotaped for further analysis. In the second visit, teachers taught a second lesson which was also videotaped. Further, selected students' notebooks were examined during the two visits to identify the content taught during the entire year. The researchers ask the teachers to select three students' notebooks that had the best representation of the content taught.

One of the lessons learned in the pilot study was that the instruments were not aligned with the content outlined by the national curricula documents. In particular, the area of statistics was underrepresented in the student test, and not present at all in the teacher questionnaire. The instruments were revised and new items were created to measure the expected outcomes in the area of statistics. Table 1 describes the expectations in this area for both countries according to their curriculum. Note that they have similar emphasis in the use and interpretation of graphical representations and measures of central tendency.

Table 1. Grade 6 expectations in the area of statistics

South Africa	Botswana
The learner: • Poses simple questions about own school and family environment, and identifies appropriate data sources. • Uses simple data collection sheets and simple questionnaires in order to collect data to answer questions posed by the teacher, class and self. • Distinguishes between samples and populations. • Organizes and records data using tallies and tables. • Examines ungrouped numerical data to determine the most frequently occurring score (mode) and the midpoint (median) of the data set in order to describe central tendencies. • Draws a variety of graphs by hand/technology to display and interpret data (grouped and ungrouped). • Critically reads and interprets data presented in a variety of ways (including own representations and representations in the media) to draw conclusions and make predictions.	Students should be able to • Read and interpret line graph representing information on everyday life. • Discuss and interpret graphs that keep record of current events. • Collect and record data in tabular form. • Identify an appropriate graph to display data. • Make conclusions about the findings of the data collected. • Find mode and median in a distribution not more than 10 numbers. • Calculate the mean of a distribution not more than 10 numbers. • Show how the mean can be used to interpret data. • Solve problems involving the mode, median and mean.

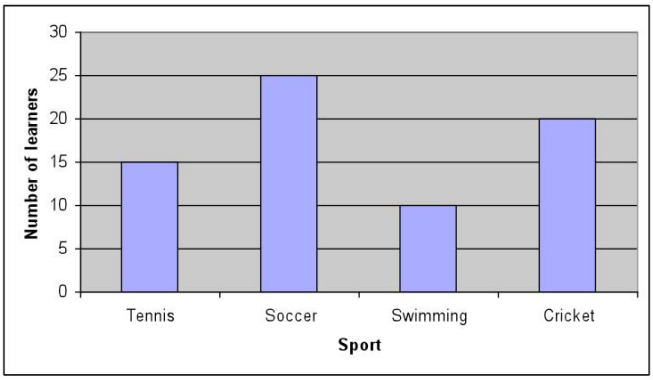
PRELIMINARY RESULTS FOR STUDENTS IN SOUTH AFRICA

The new student test included four items in statistics and one item in probability out of a total of 40 multiple-choice items. Figure 1 shows an example of one of the items designed to measure the interpretation of a bar graph. The other three were designed to measure the computation of the median and the mean and the interpretation of data presented in a table.

Even though students and teachers have been surveyed in both countries, only data from South Africa is available at this point. Botswana's local research team is still processing the data and it is still too early to present any results.

Preliminary results from South Africa indicate that students have more difficulty with the concepts of median and mean than interpreting data given in a bar graph or a table. For example 65.4% of the students responded correctly to the item presented in Figure 1 but only 16.7% could identify the median in a given set of points (Figure 2). This is consistent with classroom observations conducted in the pilot study. We observed in that occasion that in all lessons related to statistics, the teachers focus in bar and line graphs only.

Mr Khosa asked each learner in his class to name one favourite sport. He showed the information in the bar graph below.



How many learners were in Mr Khosa's class?

A. 15 B. 25 C. 60 **D. 70**

Figure 1. Grade 6 item measuring the students' ability to interpret of a bar graph

What is the median of the following data set?

9, 10, 15, 15, 20, 4, 4, 4, 5, 6, 7

A. 4 **B. 7** C. 20 D. 99

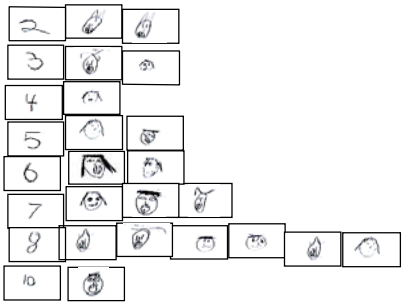
Figure 2. Grade 6 item measuring the student's knowledge of how to find the median

PRELIMINARY RESULTS FOR TEACHERS IN SOUTH AFRICA

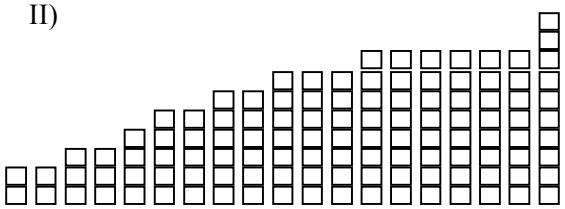
The teacher questionnaire was designed to measure three different domains of knowledge. One set of items measured sixth grade level content, a second set of items measured eighth grade level content, and the third set of items measured *knowledge for teaching*. The small body of research on the impact of teachers knowledge on student achievement have given some evidence to believe that teachers need to know not just the content they are responsible for (Grade 6 Statistics for a sixth grade teacher) but also the content at least "one level up"; and also how to apply that knowledge to teaching situations (Hill, Rowan, & Ball, 2005; Hill & Ball, 2004; Conference Board of the Mathematical Sciences, 2001). For the area of statistics, we included four items, two at the level they are teaching and two beyond Grade 6. All four items were embedded in teaching situations, so technically we can classify these items in the domain of knowledge for teaching. Figure 3 and 4 shows two of these items. Slightly different versions of these items have been used in previous comparative studies in Latin America (Sorto et al., 2009).

Imagine that two second-grade students in the same class have created the following representations to show the number of teeth lost by their classmates.

I)



II)



If the teacher wants to illustrate center and spread of the distribution of teeth lost, which representation is preferable?

a. I b. II c. I and II d. None

Figure 3. Item measuring knowledge for teaching statistics beyond Grade 6

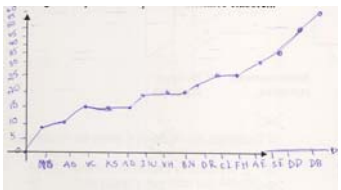
Preliminary results from South Africa teachers show an even distribution of responses. About 12.9% did not respond, 22.6% chose the first representation (correct), 24.2% chose the second representation, about 17.7% said both, 22.6% said that none of the representations is preferable. Similar results were found in Panama and Costa Rica Grade 7 teachers (Sorto et al., 2009).

A 6th grade class was wondering how much time it took each learner to travel to school each morning and collected the following data.
Learners are asked to make a graphical display of the data to show **how much time the majority of learners take to travel to school.**

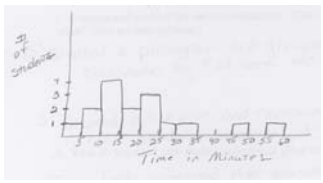
What graphical representation is the MOST appropriate for a learner to make to answer the question?

Name initials	Time in minutes
DB	60
DD	50
SE	35
AE	30
FH	25
CL	25
DR	22
BN	20
VH	20
IW	17
AS	15
KS	15
VC	15
AS	10
MS	8
RS	5

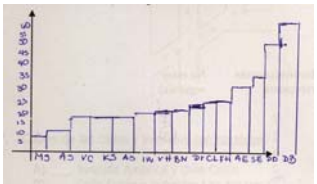
A



B



C



D

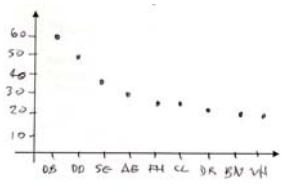


Figure 4. Item measuring knowledge for teaching statistics beyond Grade 6

For the item presented in Figure 4, only 9.7% of the South African teachers chose the histogram (B) as the most appropriate representation. The bar graph (C) was the most popular graph among all of the representations with 38.7% of the responses. Next was the line graph (A) with 25.8% of the responses. These results seem to indicate that teachers prefer bar graphs and line graphs independently of the question under consideration. It would be interesting to compare these preliminary results from South Africa with the results from Botswana and see if the same pattern holds given that Botswana teachers have a more centralized and specialized teacher preparation and training programs than South African teachers.

CONCLUSION

Preliminary results of the statistical performance of Grade 6 students in South Africa are very low, in particularly for items that measure knowledge of how to find the median and mean. The performance of teachers in items that measure content just above the grade level they have to teach is also low. The comparison with its neighbor country would shed light about why this is so. Teachers in Botswana have more specialized preparation and the hypothesis is that they will perform better than the teachers in South Africa. Once the Botswana data is available we will be able to make the final comparison.

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