LOOKING AT THE MATHEMATICS CURRICULUM AND MATHEMATICS TEXTBOOKS TO IDENTIFY STATISTICAL CONCEPTS THAT LESOTHO'S HIGH SCHOOL STUDENTS EXPERIENCE

M. V. Polaki
National University of Lesotho, Lesotho
mv.polaki@nul.ls

Recent research on Basotho pre-university students' understanding of statistical concepts has revealed some serious discrepancies. In order to lay a foundation for addressing this problem, this paper examined the nature of statistical concepts these students have experienced by looking at the high school mathematics curriculum and the type of statistical tasks used in two high school mathematics textbooks that are used in the entire country. With regard to the nature of statistical concepts covered, we found that the syllabus and the textbooks do not touch on sampling issues and related concepts. Furthermore, the statistical tasks used in the textbooks were predominantly procedural, with little or no room for data analysis, critical interpretation of the data, and statistical inferences. Additionally, both documents seemed to have paid little, if any, attention to the use of technology to support the acquisition of key statistical concepts. This paper presents these results, drawing some instructional, curricular and research implications.

INTRODUCTION

We leave in an information-driven society in which our daily decisions are premised on the ability to review, interpret, analyse, and evaluate the data from diverse backgrounds, including scientific and social contexts. Accordingly, we need citizens who are statistically literate (Murray and Gal, 2002; Schield, 2002; Watson and Moritz, 2000a). Murray and Gal point out that statistical literacy entails ability to (a) interpret and critically evaluate statistical information and data-related arguments, and (b) where relevant, to discuss or communicate their reactions to such information. The notion of sampling plays a central role in enabling students to adequately evaluate statistical claims in newspapers. They further identify two major components of statistical literacy: (a) Knowledge component which entails five cognitive elements namely, literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions, and (b) dispositional component which include critical stance, beliefs, and attitudes. Additionally, Watson and Moritz (2000b) posit that key issues related to an adequate understanding sampling includes an awareness that (a) sample size affects variation, (b) a sample might be representative of a whole, (b) there exists a hosts of other biasing factors that may affect variation.

Furthermore, recent world-wide reform efforts in mathematics education (e.g., Australian Education Council [AEC], 1994; National Council of Mathematics Teachers [NCTM], 2000) have also advocated for the expansion of middle school and high school mathematics curriculum to include key concepts of probability and statistics. For example, the NCTM declares that the teaching and learning of data analysis and probability must enable students to (a) select and use appropriate statistical methods to analyse data, (b) develop and evaluate inferences and predictions that are based on data, and (c) understand and apply basic concepts of probability. Furthermore, the ability to recognize and understand variability plays a key role in enabling people to make valid probabilistic and statistical decisions (Shaughnessy and Ciancetta, 2002). Success at making probabilistic and statistical decision is, in turn, premised on adequate understanding of the notions of sample space, variation, and probability of an event.

Although there has been some research on Lesotho's elementary and middle school l students' understanding of probability and of variability in probabilistic contexts (e.g., Polaki, Lefoka, and Jones, 2000; Polaki, 2002a, 2002b), very little research work has been done to investigate Basotho high school and pre-university students' understanding of these concepts. In an exploratory study that looked at Basotho first year university students' understanding of the ideas of sampling and variation, Polaki (2005) found that the majority of these students could neither identify nor define a sample given a contextual situation in which statistical claims were made. Furthermore, many tended to accept any documented information as true with scant regard

for some extraneous variables that have a potential to affect variation of responses and hence the validity of the some of the statistical claims made. As an extension of this study, the current study made a critical examination of the statistical concepts to which the students are exposed in their high school mathematics programme by looking at curriculum documents such as the syllabi and mathematics textbooks. This was done in order to develop a basis for making a thorough review of the school mathematics curriculum so that statistical and probabilistic concepts are given the attention they deserve.

METHODOLOGY

Following a framework of curriculum analysis used in the Second International Mathematics Study (SIMS) (Crosswhite *et al*., 1986), Flanders (1994) developed a three-dimensional model that consisted of four components: intended curriculum, implemented curriculum, tested curriculum, and attained curriculum. In essence, the model looked like the tetrahedron whose vertices were the four components. Whereas the SIMS test represented the tested curriculum, student achievement constituted the attained curriculum. Textbooks were regarded as representing the intended curriculum, and teacher activities were seen as representing the implemented curriculum. Whereas Flanders regarded textbooks as representing the intended curriculum, in this investigation textbooks are regarded as representing the implemented curriculum, given the over-reliance on textbooks by mathematics teachers. This position is grounded on the assumption that textbooks represent the curriculum in practice (Tholey, 1994; Flanders, 1987). In elaborating upon the idea of textbooks as a representation of the curriculum in practice, Tholey points out that for teachers; textbooks provide the subject matter and approaches to delivering the subject matter. Tholey further observes that, although criticized by many and applauded by others, textbook dependency is a reality to be found in many countries. Thus systematic analyses of mathematics textbooks may be used a basis for initiating and implementing far-reaching curricular reforms. Accordingly, this study was designed to critically look at the statistical concepts emphasized in the official curriculum documents and the mathematics textbooks used for teaching high school mathematics. Two mathematics textbooks that were said to cover the Cambridge Overseas School Certificate (COSC) were looked at. Both textbooks were produced by the same publisher. Textbook A was published in 1994 and had been used in the school from 1994 to 2002. Textbook B was published 2003 and had been used in the schools from 2003 to presently. In analyzing the content of each textbook 50 tasks were randomly sampled from each and then classified according to the following categories: (a) fostering procedural and computational skills, (b) using statistical methods to analyze the data, and (c) developing and evaluating inferences and predictions that are based on the data. Additionally, statistical concepts that were emphasized and those that were conspicuously missing were noted. Furthermore, the syllabus and each textbook were looked for the way they advocated the use of technology in supporting the development of statistical concepts.

RESULTS

According to the (COSC) Mathematical Syllabus D [4024] which is done in Lesotho, students should be familiar with the modes of representing the data: bar charts, pie charts, pictograms, simple frequency distributions, frequency polygons, histograms, and cumulative frequency diagrams. Additionally, they should be able to calculate the mean, median, mode, percentiles and the inter-quartile range, and to distinguish between the purposes for which each of these statistics is used. Consistent with the syllabus specifications, each textbook indeed gave a fair coverage of these concepts. What was conspicuously missing from this list of concepts was the notion of sampling, variation, and related concepts together with the use of technology to support the teaching and learning of statistics. Apparently, the students in Lesotho do not learn about sampling, variation, and related concepts until they have begun their formal introduction to statistics, and upon entering university education.

Consistent with the National Council of Teachers of Mathematics' standards (NCTM, 2000), the mathematics syllabus also asserts that the students should be able to collect, classify, and tabulate statistical data, and read, interpret and draw simple inferences from tables and statistical diagrams. To evaluate the extent to which each textbook addressed this objective, the

nature and character of the tasks used in each textbook were looked at. All the 50 tasks (100%) that were used the three exercises that were used in the statistics chapter on this book were found to be mainly procedural and computational, with little or no room for challenging the students to identify patterns on the data or to make inferences and predictions based on the data. Figure 1 shows a typical task used in the textbook. Here the students are asked to calculate the averages mean, median and mode, but are not challenged to re-interpret each of these in terms of the information they provide about the distribution in question.

The table shows the results of a survey of numbers of passengers in cars

Number of passengers	1	2	3	4	5	6
Number of cars	20	10	30	60	50	30

a) What is the variable in this question?
b) Determine the mode and the mean of this distribution.
c) Draw a cumulative frequency curve.
d) Use your diagram to find the median of the distribution.

Figure 1

It is useful to compare and contrast this task with another task that appeared in the first paper of the December 2005 COSC Mathematics written by students, the majority of whom, had been using the more recently published textbook B. In this task the students were given two cumulative frequency curves representing two distributions of the lengths of plants from fields A and B (each with some 400 plants) on the same set of axes. They were then challenged to decide which of the fields produced taller plants and to justify their decision. As a result of the fact that the task required not to calculate the median but to use the median for the purpose of comparing the two sets of data, less than 5% of about 11000 students who took the mathematics examination correctly argued that the distribution with the greatest median had the tallest plants.

CONCLUSIONS

The purpose of this study was to critically examine the mathematics syllabus and the mathematics textbook used in Lesotho to teach high school mathematics in order to determine the nature of statistics concepts used. It was found that although the syllabus does emphasize important skills such as those of collecting data, analyzing data, making inferences and predictions, the concepts of sampling, variation and related concepts are missing. Similarly, the textbook covers the notions of mean, mode, median and representation of data using bar graphs, histograms, cumulative frequency curves with no mention of sampling, variation and related concepts. The difference between the syllabus and the textbook, however, was that whereas the former emphasized the need to develop ability to analyze and interpret the data, the type of statistics tasks used in the textbook were found to be rather procedural or computational, with little or no room for comparing sets of data or making inferences or predictions based on the data. It is important to note that in Lesotho, as in many developing countries, the curriculum is not fully localized. That is, the curriculum (e.g., mathematics syllabus) and the examination are still set at Cambridge while the mathematics textbooks used in the schools are locally developed. Accordingly, it is not uncommon to find serious mismatches between syllabus specifications and the material to which the students are exposed during the lessons. Although the scope of this study may not warrant any general conclusions, the findings do suggest that `in order to strengthen the development of statistical literacy in Lesotho, the system might benefit initiating a far-reaching review of the statistics curriculum in order to include concepts and procedures that are internationally regarded to be important. Furthermore, it is important to select or develop school mathematics textbooks that are in line with syllabus specifications.

REFERENCES

Australian Education Curriculum Corporation. (1994). *Mathematics: A Curriculum Profile for Australian Schools*. Carlton, VIC: Curriculum Corporation.

Crosswhite, F. J., Dossey, J. A., Swafford, J. O., McKnight, C. C., Cooney, T. J., Downs, F. L., Grouws, D. A., and Weinzweig, A. A. (1986). *Second International Mathematics Study: Detailed Report for the United States.* Champaign, IL: Stipes Publishing.

Flanders, J.R. (1994). Textbooks, teachers, and the SIMS test. *Journal for Research in Mathematics Education,* 25, 260-278.

Murray, S., and Gal, I. (2002). Preparing for diversity in statistical literacy: Institutional and educational implications. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*, Cape Town. Voorburg, The Netherlands: International Statistical Institute.

National Council of Teachers of Mathematics (2000). *Principles and Standards for School Mathematics.* Reston, VA: Author.

Polaki, M. V. (2002). Using instruction to identify key features of Basotho elementary student's growth in probabilistic thinking. *Mathematical Thinking and Learning*, 4, 285-313.

Polaki, M. V. (2002). Using instruction to identify mathematical practices associated with Basotho elementary students' growth in probabilistic thinking. *Canadian Journal of Research in Mathematics, Science and Technology Education,* 2, 357-370.

Polaki, M. V. (2005). Basotho first year university students' ability to critique statistical claims made in newspaper reports. *Proceedings of the 1st Africa Regional Congress of the International Commission on Mathematical Instruction (ICMI),* University of Witswatersrand, South Africa.

Polaki, M. V., Lefoka, P. J., and Jones G. A. (2000). Developing a cognitive framework for describing and predicting Basotho students' probabilistic thinking, *BOLESWA Educational Research Journal*, 17, 1-20.

Shaughnessy, M, and Ciancetta, M. (2002). Students' understanding of variability in a probability environment. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*, Cape Town. Voorburg, The Netherlands: International Statistical Institute.

Schield, M. (2002). Three kinds of statistical literacy: What should we teach? In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*, Cape Town. Voorburg, The Netherlands: International Statistical Institute.

Tholey, M. (1994). The quality of textbooks: A preliminary to successful curriculum implementation. *Book of summaries of the first European Conference on Curriculum*, University of Twenty, Netherlands.

Watson, J. M., and Moritz, J. B. (2000). Developing concepts of sampling. *Journal for Research in Mathematics Education*, 31, 44-70.

Watson, J. M., and Moritz, J. B. (2000). Development of understanding of sampling for statistical literacy. *Journal of Mathematical Behavior*, 19, 109-136.