STATISTICS IN THE SOUTH AFRICAN SCHOOL CURRICULUM: CONTENT, ASSESSMENT AND TEACHER TRAINING

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In this paper the status, content and assessment of statistics in South African primary and secondary school curricula are discussed. With the new school curriculum, fully implemented in 2005, the scope of statistics has been broadened considerably; teacher training has however not yet caught up with the requirements for the teaching of the subject. A survey of teacher training programmes presented at the universities in South Africa was done to determine the status and content of statistics education in these programmes. Results show that many of these programmes do not yet train statistics teachers adequately for their task to prepare learners to be statistically literate citizens and that very few statistics education research studies on the post graduate level have been completed in the country.

INTRODUCTION

Development of a new school curriculum in South Africa started when the new post-apartheid constitution was proclaimed in 1996 (Act 108 of 1996). Outcomes-based education forms the foundation of this curriculum, known as Curriculum 2005. The curriculum was revised in 2002 and is divided into two main parts: The General Education and Training band (GET) (Department of Education, 2002a), consisting of grades R-9 (Grade R being the pre-school or reception year); and the Further Education and Training band (FET) (Department of Education, 2002b), consisting of grades 10-12. The GET band consists of three different phases, specifically the Foundation Phase (grades R-3), the Intermediate Phase (grades 4-6) and the Senior Phase (grades 7-9).

In the past, statistics in the South African mathematics curriculum in the primary school was reduced to tasks in which learners were given small organised data sets to represent in a specific kind of graph or were given graphs about which simple direct questions had to be answered. Likewise the mean, median and mode of small data sets had to be determined according to prescribed formulas, without real understanding from the teachers' or learners' side of the role and appropriateness of and differences between these measures of central tendency. The formula-based approach in the section on basic statistics measures in the senior secondary school such as mean, median, mode, range, variance and standard deviation resulted in students who were ill-prepared for statistics at the tertiary level and adults who were not statistically literate (North & Zewotir, 2006). With the introduction of the Revised National Curriculum Statement (RNCS), the scope of the Data Handling strand (Statistics) in the RNCS (grades R-9) and the National Curriculum Statement (NCS) (grades 10-12) has been broadened considerably, set against a problem solving background where statistical reasoning is encouraged. The Mission Statement of the Department of Education (www.education.gov.za/, 2008/02/27) emphasises the goal of preparing learners for social and economic needs they will face as adults: "Creating a vibrant further education and training system to equip youth and adults to meet the social and economic needs of the 21st century".

Statistics education in South Africa experienced two major initiatives in 2002. First a teacher training programme started off with the Sixth International Conference on the Teaching of Statistics (ICOTS-6), resulting in a chain of workshops, talks, seminars, visits to schools and the distribution of training manuals for teachers (North & Zewotir, 2006). Secondly the South African Census@School project initiated by Statistics South Africa provided a rich source of real data, aiming on the one hand at creating awareness for the national census in schools and on the other hand to promote statistical literacy on data collection, analysis and applications (Lehohla, 2002). Universities, however, only slowly started to incorporate statistics education courses into their formal teacher training courses.

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This paper outlines the status and content of statistics in the revised South African mathematics curriculum and discusses the role and implications of assessment in statistics in this curriculum. Finally the results of a survey of teacher training courses and post graduate research studies at South African universities are reviewed.

STATUS OF STATISTICS IN THE SOUTH AFRICAN SCHOOL MATHEMATICS CURRICULUM

In the South African mathematics curriculum statistics, or Data Handling and Probability as it is called, is included as the fourth of four learning outcomes in the FET phase, the other three being Number and Number Relationships; Functions and Algebra; and Shape, Space and Measurement. In the Foundation, Intermediate and Senior Phases Data Handling and Probability is the fifth of five learning outcomes, with Number, Operations and Relationships; Patterns, Functions and Algebra; Shape and Space; and Measurement as the other four.

Statistics Content in the South African Mathematics Curriculum

In the Foundation Phase, the focus is on using different features of objects and data to sort them in different ways. Representation of data in this phase involves a one-to-one correspondence between items in the data set and their representation. Awareness is developed of the fact that the selection of attributes used for sorting the data influences how the data are represented and how conclusions and predictions are made.

The aim of the Intermediate Phase is on acquiring skills to gather and summarise data to interpret and predict. Learners should become aware that different questions will disclose different aspects of a situation, therefore affecting the ability to understand the situation, and that different forms of representation reveal some features of the data while hiding others, limiting interpretations of the data. In this phase learners' sensitivity to the limitations that data-gathering contexts can impose on interpretation and prediction are being developed, e.g., interviewing only boys on the role of peer pressure in deciding whether or not to start smoking may give different results compared to interviewing only girls or interviewing both boys and girls (Department of Education, 2002, p. 38). Selected contexts, using discrete data involving only whole numbers, are used to build awareness of human rights and other social, economic and environmental issues. Learners' develop the ability to critically analyse data collection methods, interpretations and predictions from data. With regard to chance (probability), learners are supported in developing an awareness that different situations have different probabilities and of the finite number of different possible outcomes for some situations.

In the Senior Phase techniques learned in previous grades are used to investigate and solve problems. Learners are expected to deal with data in significant social, economic and environmental contexts, exploring relevant issues, such as HIV/AIDS, crime, abuse, and environmental issues. Learners should take a critical stance on the analysis and interpretation of data about the use, and especially the abuse, of data representation and statistics. Questions for investigation are posed, and data are gathered, summarised and represented to interpret and make predictions about situations. Both discrete and continuous data are included. The study of chance (probability) focuses on experimentation and the analysis of situations through which the learner recognises the difference between the probability of outcomes and their relative frequency in simple experiments. Both single and compound events are included. The study of probability should not merely rely on formulae but should enable learners to engage with examples and expressions of chance and probability from real life, e.g., "The HIV-test is 8% reliable".

ASSESSMENT IN THE SOUTH AFRICAN MATHEMATICS CURRICULUM

The Learning Outcomes and Assessment Standards for grades 10 – 12 have been divided into Core Assessment Standards and Optional Assessment Standards. Core Assessment Standards are examined by means of two compulsory exam papers. The Optional Assessment Standards include statistics and most of the geometry content and will be examined by means of a third optional paper from 2008 – 2010 (Department of Education, 2007, p.7). Compulsory and

Optional Assessment Standards in Learning Outcome 4, Data Handling and Probability will now be discussed by grade.

The following Core Assessment Standards are included for grade 10 (compulsory), (Department of Education, 2007, p.22):

(a) Learners should collect, organise and interpret univariate numerical data in order to determine:
    - measures of central tendency of grouped and ungrouped data and know which is the most appropriate under given circumstances;
    - measures of dispersion: range, percentiles, quartiles, inter-quartile and semi-inter-quartile range.
(b) Learners should be able to choose an appropriate type of representation such as bar graphs and compound bar graphs, histograms, frequency polygons, pie charts as well as line graphs and broken line graphs to represent data effectively.

Compulsory Assessment Standards included for grade 11 (Department of Education, 2007, p.22) are:

(a) Learners should be able to calculate and represent measures of central tendency and dispersion in univariate numerical data by :
    - five number summary
    - box-and-whisker diagrams
    - ogives
    - calculating the variance and standard deviation of sets manually (for small sets) and using available technology (for larger sets) and representing results graphically using histograms and frequency polygons.
(b) Represent bivariate numerical data as a scatter plot and suggest intuitively whether a linear, quadratic or exponential function would best fit the data.

The following Assessment Standards are optional for grades 10 and 11: All Probability Assessment Standards; the identification of possible sources of bias, errors in measurement, potential uses and misuses of statistics and charts, and the effective communication of conclusions and predictions following analysis of data and for grade 11 the differentiation between symmetric and skewed data and relevant deductions (Department of Education, 2007, pp. 25, 26).

There are no compulsory Assessment Standards for grade 12. The optional Assessment Standards for grade 12 include (Department of Education, 2007, pp. 25, 26):

- Demonstration of the ability to draw a suitable sample from a population and understand the importance of sample size in predicting the mean and standard deviation of a population.
- Using available technology to calculate the regression function which best fits a given set of bivariate numerical data.
- Using available technology to calculate the correlation co-efficient of a set of bivariate numerical data to make relevant deductions.
- Generalisation of the fundamental counting principle (successive choices from m1 then m2 then m3 . . . options create m1 x m2 x m3 . . . different combined options) and solving problems using this principle.
- Identification of possible sources of bias, errors in measurement, potential uses and misuses of statistics and charts
- Effective communication of conclusions and predictions following analysis of data
- Identification of data which is normally distributed about a mean by investigating appropriate histograms and frequency polygons.

IMPLICATIONS OF ASSESSMENT PRACTICES

The Subject Assessment Guidelines document for grades 10 – 12 mathematics states that it is anticipated that the optional Assessment Standards will become compulsory after 2010, and teachers are encouraged to prepare themselves for the teaching of these optional Standards as soon as they are confident to do so (Department of Education, 2007, pp.7, 9). In practice this assessment policy has caused many teachers to drop the optional grades 10 – 12 Assessment Standards from the curriculum. Learners who want to write the optional exam paper in grade 12 have to attend extra classes after school. Concerns are that teachers who do not teach these optional Assessment Standards for three years will have trouble doing so after 2010 if they are not involved in effective professional development programmes and that learners who haven't been taught statistics in their grade 10-12 years will not be statistically literate when they leave school and will be ill-prepared for statistics on tertiary level.

TEACHER TRAINING

Training programmes for mathematics teaching qualifications in South Africa include three options: A four year Baccalaureus degree in Education with specializations in mathematics; a three year Baccalaureus degree followed by a Post Graduate Certificate in Education (PGCE) to add a professional teaching qualification; and the Advanced Certificate in Education (ACE). In the past, quite a number of teachers only did a three-year teaching diploma, but in the new dispensation a four-year qualification is required. The ACE was introduced to assist teachers to upgrade from a three-year to a four-year qualification as well as for further specialization in a specific school subject, in this case mathematics.

INVESTIGATION

A survey was conducted to determine the statistical content and pedagogical content knowledge included in the above-mentioned university training programmes for prospective and in-service Mathematics teachers.

Method

The survey consisted of a questionnaire sent to mathematics education lecturers of the 21 universities in South Africa in which they were asked to describe the statistics content and the pedagogical content knowledge thereof taught in each of the courses described above. The survey included questions about the level and proportion of the statistics education content in the mathematics education curriculum of the presented courses and asked for a description of practical projects in them, as well as the number and topics of essays and dissertations in statistics education completed at the university. An initial analysis is below; the analysis will be finalized when all universities have responded.

RESULTS

Content and focus of the courses

Eleven lecturers from eight universities have to date responded to the questionnaire. An effort is being made to encourage all universities to respond. Follow-up telephonic interviews were conducted with five of the eleven respondents to clear up ambiguities or unclear statements in their responses. Seven of the eight universities that responded present statistics content on school level only as part of the mathematics education module and not as a separate module in the teacher training courses. Pedagogical content knowledge is included in the mathematics education modules of all the universities that responded but the level and focus differ. At three of the responding universities the development of statistical thinking and reasoning and a research based focus on how learners understand and develop specific statistical concepts form part of the pedagogical content knowledge in the course, although not on the same level as mathematical concepts. In the other universities the emphasis is on how to teach the content of the school curriculum.

At one of the universities that responded, a separate compulsory statistics education module is presented in the ACE. This module is optional for the B Ed degree. This 24-credit module includes statistics content on the first year level as well as the pedagogical content

knowledge needed to teach statistics (Learning Outcome 4) in grades 10-12. In addition to three assignments during the year and a three hour exam paper about the statistics content counting half of the course exam mark, students have to submit a portfolio consisting of descriptions of and notes on the content knowledge as well as the pedagogical content knowledge needed to teach this content for the other 50% of their exam mark. Specific lesson plans and assessment rubrics also have to be added to the portfolio. Students are required to include personal reflections on the meaningfulness of the course and have to comment on highlights and problems experienced during the course. These reflections indicate that students find the course very meaningful.

According to the survey and telephonic conversations, university lecturers in South Africa who are training pre-service and in-service mathematics teachers agree that most mathematics teachers, especially in the Intermediate and Senior Phase, do not have sufficient statistical content knowledge or pedagogical content knowledge to teach statistics with confidence. Furthermore, no information about the level of professional development of in-service teachers in statistics and statistics education in South Africa has yet been released by the Department of Education. Most of the statistics education courses have been introduced recently; therefore most practicing teachers have not had any statistics training and do not know how to teach statistics effectively.

Research studies in statistics education

The questionnaire included a question about research studies on statistics education topics done in the mathematics education departments of the universities. The only post graduate studies in statistics education, a doctoral and a masters degree, were completed by two students graduating from the specific university with a separate statistics education module presented in the ACE. The topic of the doctoral study was "Types and levels of data arrangement and representation in statistics as modeled by grades 4 – 7 learners", while the topic of the masters dissertation of limited scope was "An investigation of the role of visualization in Data Handling in grade 9 within a problem-centred context". Respondents cite the lack of student interest in such topics as the most common reason for the paucity of research in statistics education.

DISCUSSION

Almost all of the universities that responded focus in their courses exclusively on the content of the school curriculum in Data Handling and Probability (statistics) and how to teach it. Teachers need to be better prepared to teach statistics (Russell, 1990; Gattuso & Pannone, 2002; Mendonça, Coutinho, & Almouloud, 2006), and research based pedagogical content knowledge will have to be included in university courses to enable teachers to develop the statistical literacy, thinking and reasoning abilities of learners (Mickelson & Heaton, 2004). They also have to know how the different basic statistical concepts are scaffolded in a child's mind to be able to prepare statistically literate learners who will be able to be critical consumers of the data we are deluged with everyday. Ongoing professional development initiatives are crucial to address teacher knowledge; furthermore, teachers' statistical conceptions and beliefs play an important role in their teaching (Makar & Confrey, 2004; Stohl, 2005).

Regarding the paucity of post graduate studies with statistics education topics, the question can be asked whether students would still be disinterested in statistics education as a research subject if lecturers regarded it as a worthwhile subject and started researching statistics education topics themselves (Gattuso, 2006).

CONCLUSION

Statistics education in South Africa is still in its infancy, and much needs to be done to prepare mathematics teachers to teach the broadened statistics curriculum in such a way that learners are statistically literate when they leave school. University courses in South Africa will have to be aligned with the needs of the 21st century and will therefore have to be based on the growing body of recent international research in statistics education. Such an endeavour

requires the support of the National Department of Education, mathematics education departments at universities, and Statistics South Africa.

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