

# Investigating Problems Experienced by Grade 11 Mathematics Teachers in the Teaching of Probability

E.G. Makwakwa<sup>1</sup> & D. Mogari<sup>2</sup>

University of South Africa

makwaeg@unisa.ac.za<sup>1</sup> & mogarld@unisa.ac.za<sup>2</sup>

## Abstract

The study investigated problems experienced by grade 11 mathematics teachers in the teaching of probability. The study was conceptualised around notion that any changes effected on the curriculum have to happen in tandem with related teacher development initiative. The study followed a descriptive survey design that entailed the use of a questionnaire administered to a stratified sample of 100 teachers working in the Gauteng province of South Africa. Results showed that teachers had difficulties with the teaching of construction and interpretation of probability diagrams and tables; as well as the understanding and interpretation of probability terminologies.

**Keywords:** problems, probability, teaching and learning

## Introduction and Background

Probability was not taught in South African schools before 1994. It was only introduced for the first time in 2006 as a component of the mathematics syllabus at Grade 10 level. According to the National Curriculum Statement (NCS), which has been the curriculum taught in South African schools, mathematics has four learning outcomes (LO). The LOs are classified as LO1: Number and number Relationships; LO2: Functions and Algebra; LO3: Space, Shape and Measurement; and, LO4: Data handling and Probability (Department of Education [DoE], 2003). The fact that probability is new in the school curriculum implies that numerous teachers, who went through the same school system, were seeing it for the first, let alone being expected to teach it. It also means that the teachers were not taught statistics (probability implied) in their pre-service training (Mokgaphame, 2001; Owusu-Mensah, 2008). The scenario present challenges to teachers that range from teaching to assessing as stipulated by the curriculum principles and requirements (Mahlobo, 2009; Carnoy & Chisholm, 2008). There were then various in-service programmes were designed and implemented to help teachers acquire statistics knowledge for teaching, between 2008 and 2010 (DoE, 2008).

There has also been in-service training on the teaching of statistics (probability) organized by various organizations like South African Statistical Association (SASA), Statistics South Africa (Stats SA) and Association for Mathematics Education of South Africa (AMESA). According to North and Zewotir (2006: p. 5),

*these workshops cover the probability component of the NCS and are presented all year round, thus giving teachers all over South Africa the opportunity of upgrading their knowledge to achieve statistical literacy of the school leaver in South Africa.*

Amongst others, the teacher development initiative organised by AMESA include

- (i) various workshops for facilitators or subject advisors, who then provide similar training to teachers;
- (ii) supportive hour -long talks to teachers at conferences and other similar forums;
- (iii) lessons illustrating the significance of statistics as a problem solving tool; and
- (iv) demonstration lessons to teachers on how to conduct a learner-centred and interactive statistics lessons.

Also, The Institute for Science and Technology Education (ISTE) at the University of South Africa (UNISA), offers during school Winter vacations content oriented in-service training programme. ISTE determines topics to be taught during the in-service training programme through a cross-sectional survey conducted in schools across the country. Thus far probability has been one of the topics teachers considered instructionally and conceptually problematic (Atagana, Mogari, Kriek, Ochonogor, Ogbonnaya & Makwakwa, 2009; Atagana, Mogari, Kriek, Ochonogor, Ogbonnaya, Dhlamini & Makwakwa, 2010). The aim of this study was to explore problems teachers experience in the teaching of probability in grade 11.

In this study, the word problem is defined as any obstacle that can hinder the teachers' ability to teach probability. These obstacles can be manifested in the teachers' difficulty to explain concepts in probability, teachers' inability to interpret or construct probability diagrams or tables, teachers' difficulty to use formulae in calculations, teachers' difficulty to interpret or understand probability results or terminologies, etc. To this end, Cobb and Moore (1997) warn that probability is rather confusing even among those teachers who can recite the axioms of formal probability and workout textbook exercises. Hence, there is a need to pursue a study that seeks to look into problems encountered in the teaching of probability.

### **Literature Review**

The literature review for the study is presented to justify the need for the study and establish a link between existing literature and the study.

### **Why a need for the study**

In-service training programmes are seen by teachers as the remedies to their teaching problems (Atagana et al., 2009: 40). It is through such programmes that teachers are able to expand their subject matter knowledge, develop new knowledge and help teachers plan and thoroughly develop their own work (Owusu-mensah, 2008). Effective and meaningful in-service training programmes can identify teachers' needs by collecting information about problems they encounter in teaching (Owusu-mensah, 2008). This study is meant to sketch a bigger picture for in-service training organisers about the aspects of probability that teachers encounter problems with.

### **A link between the study and literature**

Various studies have been conducted on problems experienced by mathematics teachers when teaching statistics (probability implied) (see, for example, Garegae, 2008; Atagana et

al., 2009; Atagana et. al., 2010; Wessels & Nieuwoudt, 2011). Garegae (2008) studied challenges mathematics teachers experience when teaching statistics. Her study showed that mathematics teachers in high schools face problems in explaining concepts to learners; solving problems from past examinations papers; coming out with appropriate activities for learners; figuring out syllabus objectives; and relating the teaching of statistics to real-life.

Atagana and his team studied perceived difficult topics by learners and teachers in the teaching and learning of mathematics (Atagana et al, 2009). They undertook a similar study a year later with the objectives altered and a much more geographical diversified sample of teachers, where teachers from other provinces were included in the study. One of the study objectives was to “to identify the topics that teachers have difficulties in teaching in Mathematics, Science, and Technology at FET phase (Grades 10 - 12) and GET phase (Grades 8 and 9)” (Atagana et al., 2010). The results revealed that probability is one such topic.

Wessels and Nieuwoudt (2011) studied the profile of mathematics teachers’ statistical knowledge, beliefs and confidence in order to inform the development of in-service teacher education programmes in statistics for grade 8 and grade 9 teachers. They found that the teachers show high levels of confidence in teaching most statistics topics and low levels of statistical thinking when they had to apply their knowledge of concepts, such as sample and average in social contexts including newspaper articles and research reports. Wessels and Nieuwoudt also reported that more teachers indicated lower levels of confidence in sampling, and probability topics (probability language, basic probability calculations).

Indeed, the studies by Wessels and Nieuwoudt (2011) and Atagana et al (2010) do present findings on challenges posed by probability to teachers. The challenges however were only sourced from teachers. The current intends to include learners as well in order to provide a broader perspective on problems associated with probability teaching.

### **Conceptual Framework**

The study has been conceptualised around the notion that there need for a link between changes made in the mathematics curriculum and teacher development. Both pre-service and in-service teacher programmes have to be based on what is taught or reflect what happens in class. That is, during pre-service teacher education, teacher trainees have to be taught aspects of the curriculum in addition to professional training that deals with teaching methodologies and to teaching further content knowledge meant to enrich and consolidate the teacher trainees’ subject matter knowledge. In-service teacher education has to keep abreast of developments taking place in the mathematics curriculum. It is through in-service teacher education that teachers are kept up to date with changes made in the curriculum as well as ensuring that teachers are always ready and well prepared to deliver the newly fashioned curriculum.

It will be suicidal for teacher education not to work in tandem with school mathematics curriculum. Put it differently, for teacher education to ignore what is happens in the school mathematics curriculum is counter-productive. Teachers may find themselves not being in a

position to teach aspects of the curriculum largely because of their deficient content knowledge or pedagogical knowledge or even both.

Another factor to consider is that teachers tend to be enthusiastic with what is being taught during in-service teacher programme if it has any relevance to what they do in class. Teachers would therefore display positive attitude and probably participate with interest in the programme. Then, there is a strong likelihood that teacher will effectively learn what is being taught to them. When what happens during in-service teacher programme is not related to any aspects of the school mathematics curriculum, teachers may switch off and just flow along with the activities of the programme. Upon return to their class routines it will be business as usual.

On the other hand, before changes are in made in the school mathematics curriculum teachers first have to be made aware of the changes and how to manage the changes. That is, teachers have to be taught about the changes as well as how to teach the changed aspects of the curriculum. Otherwise, teachers are most likely to encounter difficulties with the teaching of the newly introduced aspects of the curriculum. It is this that forms the backdrop of this study.

## **Methodology**

### **Study design**

The study followed a descriptive survey research design. Participants were requested to complete a questionnaire. The questionnaire elicited teaching problems experienced in the teaching of probability in schools.

### **Sample**

The target population of this study consisted of grade 11 mathematics teachers from public schools in the Gauteng Province. Public schools are government-aided to some extent where government provides the minimum, and parents contribute to basics and extras in the form of school fees (Education, 2010). Government also assists teachers from public schools with funds to attend the educational development programmes to improve the teachers' knowledge. A stratified sampling technique was used to select a sample of 100 teachers consisting of 58 males and 42 females. The sample was classified in to two subgroups (50 teachers per stratum) based on schools' geographical location namely township and urban.

### **Instrument**

The study used a teacher questionnaire to collect data on aspects of probability. The questionnaire consisted of 15 items on aspects of probability taught in Grade 11 mathematics. Respondents had to indicate their competence on a Likert type scale. For instance one item relating to (two –way contingency tables) was: *Teaching learners to construct two –way contingency tables from a given word problem*. Another item relating to (mutually exclusive events) was: *Teaching learners to identify mutually exclusive events from Venn diagrams*. The Likert type scale was anchored by 1= Not all competent and 4= very competent.

### Validity and reliability of instrument

The teacher questionnaire was validated using content and construct validity. Content validity was carried out by involving experts in statistics and statistics education field. Each expert was given a validity form to judge whether the questionnaire measured the intended content area of the study (cf. Gay & Airasian, 2003). For construct validity, a factor analysis was performed to ascertain if the individual questions contribute on to the dimensions as in the questionnaire. The analysis was computed by using Statistical Package for the Social Sciences (SPSS). Reliability was determined by computing Cronbach's (1951) alpha as a measure of the internal consistency of scores from the questionnaire. The value of alpha was 0.93. This value was seen to be excellent based on the rule of thumb "...  $\alpha > .9$  – Excellent,  $\alpha > .8$  – Good,  $\alpha > .7$  – Acceptable,  $\alpha > .6$  – Questionable,  $\alpha > .5$  – Poor, and  $\alpha < .5$  – Unacceptable" (George & Mallery, 2003, p. 231).

### Data Analysis

Descriptive statistics (frequencies) were used to analyze the data collected. The percentages of the teachers' actual problems in the teaching of probability are reported in Table 1.

**Table 1: Teachers' problems in teaching probability (n=100)**

Scale items	%
Teaching learners to construct Venn diagram from a given word problem.	54.0
Teaching learners to construct two –way contingency tables from a given word problem.	68.0
Teaching learners to construct tree diagrams from a given word problem.	63.0
Teaching learners to use two –way contingency tables for problem solving.	72.0
Teaching learners to use Venn diagrams for problem solving.	64.0
Teaching learners to use tree diagrams for problem solving.	62.0
Teaching learners to identify dependent and independent events from Venn diagrams.	57.0
Teaching learners to Identify dependent and independent events from two-way contingency tables.	62.0
Teaching learners to use Venn diagram to solve probability problems where events are not necessary independent.	68.0
Teaching learners to use tree diagrams to solve probability problems where events are not necessary independent.	65.0
Teaching learners to calculate the probability of two independent event by applying product rule for independent events: $P(A \text{ and } B) = P(A) \cdot P(B)$	66.0
Teaching learners to identify mutually exclusive events from Venn diagrams.	67.0
Teaching learners to differentiate between independent and dependent events.	69.0

The table shows that 54% of the teachers are not competent with teaching learners to construct Venn diagram from a given word problem; 68% are not competent with teaching learners to construct two-way contingency tables from a given word problem; 63% are not competent with teaching learners to construct tree diagrams from a given word problem; 72% are not competent with teaching learners to use two-way contingency tables for problem solving; 64% are not competent with teaching learners to use Venn diagrams for problem solving; 62% are not competent with teaching learners to use tree diagrams for problem solving).

Table 1 also shows that 69% of the teachers are not competent with teaching learners to differentiate between independent and dependent events; 68% are not competent with teaching learners to use Venn diagram to solve probability problems where events are not necessarily independent; 67% are not competent with teaching learners to identify mutually exclusive events from Venn diagrams; 66% are not competent with teaching learners to calculate the probability of two independent event by applying product rule for independent events; 65% are not competent with teaching learners to use tree diagrams to solve probability problems where events are not necessarily independent; 62% are not competent with teaching learners to identify dependent and independent events from two-way contingency tables; 57% are not competent with teaching learners to identify dependent and independent events from Venn diagrams.

## Discussion

In Grade 11 the chapter on probability is about a number of activities. These relate to dependents and independents events from two-way contingency tables and Venn diagrams; calculate the probability of two independents events occurring by applying the product rule for independents events; use tree and venn diagrams to solve probability problems (De Jager, Dewet & Raubenheimer, 2006). On the contrary, Table 1 above shows that more than 50% of the respondents ( $n = 100$ ) have various problems with construction/interpretation of probability diagrams and tables; and understanding/interpretation of probability terminologies. This finding is in agreement with the findings of Wessels and Nieuwoudt (2011) which states that more teachers indicate lower levels of confidence in probability language and basic probability calculations. According to Nicholson and Darnton (2003), statistics may pose particular problems if the teacher has not studied statistics, which in South African school mathematics curriculum is taught as part of mathematics. Also, if the teacher is not a statistics subject specialist problems may be experience because teaching mathematics and statistics is different compared with other subjects. The difference is mainly with regard to emphasis on concepts and ways of knowing (Garegae, 2008). Obviously the statistics content problems teacher have, means that changes were made in the mathematics curriculum without first mounting an appropriate in-service teacher programme to orientate teachers to the desired changes and ensuring that teachers can handle the changes. In other words, it seems statistics was introduced without first ascertaining that teachers know it as well as being able to teach it. Ideally, in-service teacher programme should precede implementing changes in the class, otherwise teachers will encounter difficulties managing the effected chnages. This study recommends that the topics identified here should be taught in the in-service training programmes.

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## References

- Atagana, H. I., Mogari, L. D., Kriek, J., Ochonogor, E. C., Ogbonnaya, U. I., & Makwakwa, E. G. (2009). *An analysis of educators' and learners' perceived difficult topics in mathematics, physical science and life science at the Further Education and Training (FET) band in Gauteng province: A Report of the ISTE 2009 Winter School.*
- Atagana, H. I., Mogari, L. D., Kriek, J., Ochonogor, E. C., Ogbonnaya, U. I., Dhlamini J.J, & Makwakwa, E. G. (2010). *An intervention into educators' and learners' difficulties in some topics in mathematics, science and technology: A report of the ISTE 2010 Winter School.* ISBN: 978-1-86888-684-5.
- Carnoy, M., & Chisholm, L. (2008). *Towards understanding student academic performance in South Africa: A pilot study of grade 6 mathematics lessons in South Africa. Report prepared for the spencer foundation.* Pretoria: HSRC.
- Cobb, G. W., & Moore, D. S. (1997). Mathematics, Statistics, and Teaching. *JSTOR*, 104 (9), 801-823.
- Cronbach LJ 1951. Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297 – 334.
- De Jager, M., Dewet, C., & Raubenheimer, L. (2006). *OBE for FET Mathematics: Grade 11 Learner's Book.* Pretoria: Nasou Via Africa (Pty) Ltd.
- Department of Education. (2003). *National Curriculum Statement grades 10-12 (General). Mathematics.* Pretoria, South Africa.
- Department of Education. (2008). *National Curriculum Statement grades 10-12 (General) Subject Assessment Guidelines: Mathematics.* Pretoria: Department of Education.
- Education Foundation. (2010). *Education in South Africa. Big Media Publishers, South Africa.*
- Gay, L. R., & Airasian, P. (2003). *Educational research: Competencies for analysis and applications. Seventh Edition.* Upper Saddle River, New Jersey: Pearson Education, Inc.
- Garegae, K. G. (2008). Training statistics teachers for Botswana senior schools: is it necessary?. In C. Batanero, G. Burril, C. Reading & A. Rossman (Eds.). *Proceedings of the ICMI Study 18 and 2008 IASE Round Table Conference.* ICMI/IASE.
- George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. 11.0 update (4th ed.).* Boston: Allyn & Bacon.
- Mahlobo, R. K. (2009). *A model for an open-ended task-based approach in grade 11 mathematics classes.* University of North West. Potchefstroom : Unpublished PhD Thesis.
- Mokgaphame, P. M. (2001). *The management of OBE teacher training in the North Province.* Pretoria: University of South Africa: Unpublished Masters dissertation.
- Nicholson, J., & Darnton, C. (2003). Mathematics teachers teaching statistics: What are the challenges for the classroom teacher? *International Association for statistical Education.* Berlin.
- North, D., & Zewotir, T. (2006). *Introducing statistics at school level in South Africa.* Salvador, Bahia: IASE, ISI. ISBN-10: 90-73592-24-0, ISBN-13: 978-90-73592-24-7.
- Owusu-Mensah, J. (2008). *A critical investigation into the nature and quality of in-service education and training programmes for Further Education and Training (FET)*

*mathematics teachers in the Greater Taung area*. Pretoria: University of South Africa:  
Unpublished Masters dissertation.

Wessels, H., & Nieuwoudt, H. (2011). Teachers' professional development needs in data handling and probability. *Pythagoras*, 32(1), pp. 1-9.