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The Use of the Subject Assessment Guidelines for Mathematics Taxonomy in Developing Statistical Learning Outcomes for Grade 12 Learners
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KEYWORDS Subject Assessment Guidelines for Mathematics taxonomy and statistical learning outcomes.

ABSTRACT In this paper the use of the Subject Assessment Guidelines for Mathematics (SAGM) taxonomy in developing statistical learning outcomes (SLO) for grade 12 learners is investigated. A literature on SAGM taxonomy and the SLO was reviewed. Further, a case was made for using the SAGM taxonomy and the SLO in writing assessment items in teaching statistics. It is argued that SAGM taxonomy uses four cognitive levels, knowledge, routine procedures, complex procedures and solving problem. Furthermore it is argued that the use of the three SLO, statistical literacy, reasoning and thinking to distinguish between learning outcomes is helpful in teaching statistics. A qualitative content analysis obtained from the 2010 and 2011 Grade 12 mathematics examination papers was done to also examine the use of SAGM

taxonomy in developing the SLO. Results show that the SAGM taxonomy should be used in developing statistical literacy, reasoning and thinking. Mathematics teachers should be trained to use both, the SAGM taxonomy and the SLO in statistics assessment.

INTRODUCTORY ~~BACKGROUND~~

The National Curriculum Statement in South Africa includes Statistics in Further Education and Training (FET) Mathematics Curriculum (DOE, 2003). The National Department of Education publishes Subject Assessment for Mathematics (SAGM) taxonomy designed for use in constructing and assessing Mathematics (NCS, 2008). The SAGM taxonomy merges cognitive level with the type of mathematical activity. Teaching Statistics as part of the FET Mathematics curriculum required also the use of the SAGM taxonomy in writing assessment. Recently more attention has been paid to Statistics, which in most countries is taught as part of Mathematics Curriculum. Many recommendations have been given for how Statistics course should be taught, as part of the general reform movement. One of the recommendations is the focus on developing statistical literacy, reasoning and thinking (Ben-Zvi & Garfield, 2004). These statistical learning outcomes (cognitive outcomes), distinguish between desired learning outcomes both in considering instructional goals and writing assessment (delMas, 2002). The aspect of using the SAGM taxonomy in designing assessment in Statistics suggests considering the development of statistical learning outcomes.

In 1995 the South African government brought about a new Mathematics curriculum that includes Statistics and probability in the Further Education and Training (FET) Mathematics curriculum. This inclusion of Statistics and probability in the FET sector put specific demands on the teachers (DOE, 2003:4). This is in line with curriculum innovations in other international settings. For instance, in the United State, statistical proficiency as well as learners' understanding of and skill in working with Statistics is strongly supported (National Council of Teachers of Mathematics (NCTM), 2000). In New Zealand, the new school curriculum implicitly supports new approaches to statistics and emphasises the changes needed in both the pedagogy and thinking behind statistics education and the urgent need for statistics education for critical citizenship (Ministry of Education, 2007).

In South Africa, teachers are encouraged to use the Subject Guidelines for Mathematics as they prepare to teach Mathematics (Statistics). According to the NCS (2008), teachers should also use every available opportunity to hone their assessment skills in Mathematics (Statistics). These skills relate both to the setting and marking of assessment tasks. Assessments should cater for a range of cognitive levels and abilities of learners (NCS, 2011:53). A challenge for South Africa is when writing assessment in Statistics, the SAGM taxonomy and the SLO should be kept in mind. One cannot be part of writing the assessment without involving the other. In this paper we consider the use of the SAGM taxonomy in developing statistical literacy, reasoning and thinking in writhing assessment in statistics.

OBJECTIVES OF THE STUDY

This study sought to investigate the use of the SAGM taxonomy in developing statistical literacy, reasoning and thinking. In this paper, we would like to know if there is a possibility for the four levels of cognitive demand for Mathematics to be used in developing statistical literacy, reasoning and thinking. The answers to this is related to how the literature elaborates on SLO and on SAGM taxonomy, and also to the results of the qualitative analysis of 2010 and 2011 grade 12 Mathematics examination papers.

From the above discussion, this research was guided by the following question:

- Can the SAGM taxonomy be used in developing statistical literacy, reasoning and thinking?

LITERATURE REVIEW

Literature reviewed two concepts, namely the Subject Assessment Guidelines for Mathematics (SAGM) taxonomy and the statistical learning outcomes. The learning outcomes are defined as the end product of a learning process (SUVCA, 2000). Outcomes define the result that learners must achieve as a result of learning opportunities in terms of knowledge, skills, competencies and attitudes (Bodenstein, 1999). In the process of determining the outcomes, one should ensure that all six levels of Bloom's taxonomy of cognitive skills are considered (Forehart, 2005), i.e. levels of knowledge, comprehension application, analysis, synthesis and evaluation. Bloom (1995) talked about cognitive outcomes as learning outcomes which involve intellectual skills

and which can be classified in hierarchy from 'lower-order' to 'higher order' skills; knowledge, comprehension application, analysis, synthesis and evaluation. Describing these cognitive levels as actions (using verbs), one gets a good idea of the intellectual skill that are characterised thereby. When stating assessment criteria cognitive skills and/or actions should be kept in mind.

SAGM taxonomy

Within Mathematics, a number of different taxonomies have been developed for various purposes. In South Africa, the National Department of Education published a Subject Assessment Guidelines for Mathematics (SAGM) taxonomy designed for use in constructing and assessing the grade 12 final Mathematics examinations. This taxonomy provided in the Subject Assessment Guidelines for Mathematics document uses the four cognitive levels to guide all assessment tasks based on those suggested in the TIMSS study of 1999 **(**NCS**,** 2008). The four cognitive levels are as follow, knowledge, routine procedures, complex procedures and solving problems (see Table 1).

Table 1: The SAGM taxonomy (NCS, 2008)

COGNITIVE LEVELS	**EXPLANATION OF SKILLS TO BE DEMONSTRATED**
KNOWLEDGE (25%)	- Algorithms - Estimation; appropriate rounding of numbers - Theorems - Straight recall - Identifying from data sheet - Simple mathematical facts - Know and use of appropriate vocabulary - Knowledge and use of formulae All of the above will be based on known knowledge.
ROUTINE PROCEDURES (30%)	- Problems are not necessarily unfamiliar and can involve the integration of different LOs - Perform well-known procedures - Simple applications and calculations which must have many steps and may

	require interpretation from given information - Identifying and manipulating of formulae All of the above will be based on known procedures.
COMPLEX PROCEDURES (30%)	Problems are mainly unfamiliar and learners are expected to solve by integrating different LOs - Problems do not have a direct route to the solution but involve: • using higher level calculation skills and reasoning to solve problems • Mathematical reasoning processes - These problems are not necessarily based on real world contexts and may be abstract requiring fairly complex procedures in finding the solutions.
SOLVING PROBLEMS (15%)	Solving non-routine, unseen problems by demonstrating higher level understanding and cognitive processes - Interpreting and extrapolating from solutions obtained by solving problems based in unfamiliar contexts - Using higher level cognitive skills and reasoning to solve non-routine problems - Being able to break down a problem into its constituent parts – identifying what is required to be solved and then using appropriate methods in solving the problem - Non-routine problems be based on real contexts

These four cognitive levels are ordered by the nature of the activity required to complete the task successfully. They emphasise that Mathematics learner should be challenged to develop knowledge and skills. The descriptors used in this SAGM taxonomy are summarised below (NCS, 2011):

Knowledge (25%): This involves straight recalling previously learned information in the original form, for example, remembering a median, and the formula to use for the mean. In order to

demonstrate knowledge learners should be able to recognise concepts, understand the meaning of symbols in a formula, substitute into a formula. Learners should be able to use simple Mathematics facts.

Routine procedures (30%): This involves working with material in a way that goes beyond the simple recall of facts. Learners are required to carry out all the steps in a procedure, which may contain a number of underlying processes. All learners who use the procedure correctly will get the correct answer (although there may be more than one appropriate procedure for a particular problem). Learner will have used the procedures in drill exercises prior to the assessment.

Complex procedures (30%): This involves the ability to choose and apply knowledge and skills appropriately in a new situation, problems are mainly unfamiliar and learners are expected to solve by integrating different learning outcomes; these problems do not have a direct route to the solution but involve, using higher level calculation skills and reasoning to solve problems and mathematical reasoning processes; and these problems are not necessarily based on real world contexts and may be abstract requiring fairly complex procedures in finding the solutions.

Solving problem (15%): Learners should be able of solving non-routine, unseen problems by demonstrating higher level understanding and cognitive processes; interpreting and extrapolating from solutions obtained by solving problems based in unfamiliar contexts; using higher level cognitive skills and reasoning to solve non-routine problems; being able to break down a problem into its constituent parts and identifying what is required to be solved and then using appropriate methods in solving the problem; and non-routine problems be based on real contexts

If the SAGM taxonomy can be used in Mathematics class to complete the task successfully, and the four cognitive levels emphasise that Mathematics learner should be challenged to develop knowledge and skills this can also be the case in Statistics class. According to the NCS (2008) the SAGM taxonomy conflates cognitive levels with type of mathematical activity. This assumption is also extended to the statistical activity where cognitive levels are used in writing assessment (NCS, 2011: 48). Assessment of student learning is an important part in every educational process as it provides information about student achievement in relation to the

intended learning outcomes. Consequently, assessment has received much attention in Statistics education in recent years (see, for example, Gal & Garfield, 1997).

Statistical learning outcome (cognitive outcome)

The discipline of Statistics is ideally suited to provide a wide variety of assessment opportunities (Bidgood & Hunt, 2009). Different Statistics topics will require different assessment guidelines. Therefore specific guidelines within a discipline appear to be more useful than the six general categories in Bloom's taxonomy (delMas, 2002). delmas (2002) conceptualise goals of instruction in teaching statistics into three statistical learning outcomes (cognitive outcomes), statistical literacy, reasoning, and thinking. These three statistical learning outcomes appear to coincide, to some extent, with Bloom's general categories with statistical literacy regarded as consistent with the "knowing" category, statistical reasoning as consistent with the "comprehending" category (with perhaps some aspects of application and analysis), and statistical thinking as encompassing many elements of the top three categories of Bloom's taxonomy (see Table 2).

Table 2: Statistical learning outcomes (delMas, 2002)

Categories of learning	**Statistical learning outcomes**	**Words (verbs) that provide orientations**
Knowledge	Statistical literacy	identify, construct, describe, display, interpret, list, name, organise, recognize, rephrase, translate
Comprehension (application and Analysis)	Statistical reasoning	compare, explain why or how, infer, predict, summarize
Application (Analysis, synthesis and evaluation)	Statistical thinking	analyze, apply, critique, evaluate, estimate, determines, decompose/compose, generalise

In South Africa, in the Further Education and Training band, the National Curriculum Statement (DOE, 2003), stipulates that learners will master further methods of organising, displaying and

analyzing data. Measures of central tendency and spread will be explored. A basic appreciation of the difference between data that is normally distributed about a mean and data that is skewed will be developed. Learners will become critically aware of the deliberate abuse in the way data can be represented to support a particular viewpoint. Learners will carry out practical research projects and statistical experiments. A project each year will involve the selection of a random sample of a specific population with a view to determining statistics that predict the corresponding parameters of the population. These help to develop learners' statistical literacy, reasoning and thinking.

In modern statistics education statistical literacy, reasoning and thinking are introduced as more desirable learning outcomes (Ben- Zvi and Garfield, 2004). Over the past years much attention has been paid to statistical literacy, reasoning, and thinking. These terms are often used interchangeably and used differently by different people (e.g., Cobb 1992; Pfannkuch and Wild 1998; Garfield and Gal 1999). Yet, there is no formal agreement regarding the definitions and distinctions of these terms. Although there is no formal agreement, the definitions used in this study are drawn from Chance, delMas and Garfield (2003):

- Statistical literacy includes basic and important skills that may be used in understanding statistical information or research results. These skills include being able to organise data, construct and display tables, and work with different representations of data. Statistical literacy also includes an understanding of concepts, vocabulary and symbols, and of probability as a measure of uncertainty.
- Statistical reasoning may be defined as the way in which people reason with statistical ideas and make sense of statistical information. This involves making interpretations based on sets of data, representations of data, or statistical summaries of data. Statistical reasoning may involve connecting one concept to another (for example, centre and spread), or it may combine notions about data and chance. Reasoning means understanding and being able to explain statistical processes and fully interpret statistical results.
- Statistical thinking involves an understanding of why and how statistical investigations are conducted and the "big ideas" that underlie statistical investigations. Statistical thinking involves an understanding of the nature of sampling, how inferences are made from samples to populations, and why designed experiments are necessary in order to establish causation.

Statistical thinking includes an understanding of how models are used to simulate random phenomena, and how, when, and why existing inferential tools can be used to aid an investigative process. Statistical thinking also includes being able to understand and utilise the context of a problem in forming investigations and drawing conclusions, and recognising and understanding the entire process. Finally, statistical thinkers are able to critique and evaluate results of a problem solved or a statistical study.

Aspects of Chance, delMas and Garfield's notion of statistical literacy, reasoning and thinking have been incorporated in The National Curriculum Statement in South Africa (DOE, 2003), which require learners to be able to: collect and use data to establish basic statistical and probability models, solve related problems, and critically consider representations provided or conclusions reached; solve non-routine, unseen problems using mathematical principles and processes; investigate historical aspects of the development and use of Mathematics in various cultures; and use available technology (the minimum being a modern scientific calculator) in calculations and in the development of models. Furthermore, according to the DOE (2003), when teachers/assessors prepare an assessment task or question, they must ensure that the task or question addresses an aspect of a particular outcome.

From this delMas (2002) came with a list of words that provide orientations requiring learners to demonstrate or develop an understanding in statistical literacy, reasoning and thinking (see Table 2). These words (verbs) could also be identified in the NCS (2008, 2011) document where examples of the types of questions that can be set for each of the four categories of mathematical demand where given. If an outcome is to develop statistical literacy, then teachers can ask learners to identify examples or instances of a term or concept; describe graphs, distributions, and relationships; rephrase or translate statistical findings, or interpret the results of a statistical procedure. Furthermore, if learners are asked to explain why or how results were produced or why a conclusion is justified, they are developing their statistical reasoning. For Chance (2002), in statistical thinking, learners are asked to apply their statistical literacy and reasoning in context. As such, statistical thinking is promoted when instruction challenges learners to apply their understanding to real-world problems, to critique and evaluate the design and conclusions of studies, or to generalise knowledge obtained from classroom examples to new and somewhat novel situations.

Therefore, teachers must perceive the nature of the task in order to identify whether instruction promotes literacy, reasoning, or thinking. Similarly, the nature of a test item determines which of the three learning outcomes is assessed and may allow for more than one learning outcome to be assessed by the same item. The SAGM taxonomy cognitive levels and the statistical learning outcomes can be used in writing assessment in Statistics. In the process of determining the statistical learning outcomes, one should ensure that all these four cognitive levels are considered.

METHODOLOGY

Design and method

This was a qualitative document analysis to investigate the use of the SAGM taxonomy and the SLO. Data were qualitatively analysed using the 2010 and 2011 grade 12 Mathematics examination questions. The purpose of the qualitative analysis was to identify the statistical learning outcomes and SAGM taxonomy levels involved in these two examination papers. This study focused on Statistics in the Mathematics curriculum that was tested in the two grade 12 Mathematics second papers.

PROCEDURE

Permission for the study was granted by the Free State Department of Education. The researcher personally analysed the 2010 and 2011 November grade 12 Mathematics examination papers. Number of questions in the 2010 and 2011 grade 12 Mathematics examination papers was determine by considering only the Statistics questions involved. In order to examine the SAGM taxonomy involved in the two examination papers, the number of sub-questions done on different levels of cognitive demand (knowledge, routine procedures, complex procedures, problem solving) from each question was recorded from the 2010 and 2011 grade 12 Mathematics examination papers. To examine the SLO, Statistics questions in the two examination papers were numbered starting from the 2010 up to the 2011 examination papers. Words (coding units) that provide orientations requiring learners to demonstrate or develop an understanding in statistical literacy, reasoning and thinking were identified from the numbering of the 2010 and 2011 grade 12 Mathematics examination papers.

PRESENTATION AND ANALAYSIS OF RESULTS

Analysis of SAGM taxonomy in the 2010 and 2011 grade 12 Mathematics examination paper

In the 2010 examination paper

In question 1, all the three sub-questions weighted 30%. The fact that learners have demonstrated that they know and use appropriate vocabulary, Identify statistical concepts from data sheet, led to classify this problem as a ”Knowledge” in the SAGM taxonomy. In this question 1, learners were given data in the table for class A and box whisker diagram for class B. Learners were asked to write down the five number summary for class A (question 1.1), to draw box whisker diagram for class A (question 1.2), and to determine which class performed better in the June examination and give reasons for their conclusion (question 1.3). In question 1.1, it is of courses, possible for learners to identify the maximum, the minimum, the median, use the formulae to find quartile 1 and quartile 2. In order to draw the box and whisker diagram in question 1.2, learners needed to use the five number summary for class A. Here learners needed to know the appropriate meaning of the box and whisker diagram. Furthermore, in question 1.3, learners needed to use simple mathematical facts to determine that class B performed better then class A, the reason being because half of the learners get above 60%. In this question the results in class B skewed more to the left that of class A.

Question 2 weighted 26.7%. In this question the facts that problems are mainly unfamiliar and learners are expected to solve by integrating different learning outcomes, led to classify this problem as a ” complex procedures” in the SAGM taxonomy levels. Problems do not have a direct route to the solution but involve: using higher level calculation skills and reasoning to solve problems and mathematical reasoning processes. In this question data is represented in the histogram. Learners were asked to complete the cumulative frequency table for the given data (question 2.1), to draw an ogive (question 2.2) for the given data, to use the ogive to estimate how many learners scored 75% or more for the examination (question 2.3). In question 2.1 and 2.2, learners needed to solve the two questions by integrating different learning outcomes, using higher level calculation skills and reasoning to solve problems. Here learners needed to complete the cumulative frequency table by calculating the cumulative values. Further, learners needed to use the data from the cumulative frequency table to draw an ogive representing the cumulative

frequency against the examination scores. In question 2.3, learners needed to use higher level mathematical reasoning processes to estimate that 36 learners scored 75% or more for the examination.

The problem in question 3 weighted 23.3% and classified as “routine procedures” in the SAGM taxonomy. What we see here problems are not necessarily unfamiliar and can involve, the integration of different leaning outcomes, performing well-known procedures, simple applications and calculations which must have many steps and may require interpretation from given information, identifying and manipulating of formulae. In this question 3, the data in the table, learners were asked to calculate the mean (question 3.1), the standard deviation (question 3.2) for the data, and to find the maximum number of liters of ice cream that the owner must stock per day in order to be within one standard deviation of the mean (question 3.3). In order to solve question 3, learners needed to know procedures to calculate the mean (question 3.1). They also needed to use simple applications and calculations which must have many steps and may require interpretation from given information to calculate the standard deviation (question 3.2). Here learners needed to use a calculator or a pen and paper method. Finally, learners needed then to interpret the data by finding that the maximum number of liters of ice cream that the owner must stock per day in order to be within one standard deviation of the mean is 237,70 litres (question 3.3).

Question 4 weighted 20% and categorised as “solving problems” in The SAGM taxonomy. At this level learners are involve in solving non-routine unseen problems be based on real contexts by demonstrating higher level of understanding and cognitive processes, Interpreting and extrapolating from solutions obtained by solving problems based in unfamiliar contexts. In this question the information is summarised in the grid. Learners were asked which airline has the worst for on-time arrival (question 4.1), learners were asked if the statement given in this question is true and they have to motivate their answer (question 4.2). Learners were asked ‘does the data confirm the research’s suspicious? Justify your answer’ (question 4.3). Finally learners were asked ‘which one of the 10 airlines would you prefer to use and give reason for your answers’ (question 4.4). In question 4.1, 4.2 and 4.3, the problem is based on real context. Here learners needed to demonstrate higher level of understanding and cognitive processes. Fly high airline has the worst for on-time arrival (question 4.1). In question 4.2, learners needed to say yes the statement given is true and show that 40 passengers lost their luggage. In question 4.3 the

answer is yes, the reason because of the weak negative correlation r = -0.2128075984. In question 4.4, the problem required learners' interpretation and extrapolation from the data represented in the histogram. Learners need to say Alpha, because Alpha is 70% on-time arrival and has least luggage loss.

In the 2011 examination paper

Question 1 weighted 30% and categorised as "knowledge" in the SAGM taxonomy. The skills to be demonstrated by learners are; know and use of appropriate vocabulary, Identifying from data sheet and Know and use of appropriate vocabulary. In question 1, learners were given data in the table and are asked to determine the median (question 1.1), the inter quartiles (question 1.2), to draw the box and whisker (question 1.3) and finally to use the box and whisker diagram to comment (q 1.4). In this question learners needed to identify the mean (question 1.1) and the quartiles (question 1.2) from the data given in the table. Learners needed to determine the inter-quartile range knowing the appropriate meaning of inter-quartile range. Furthermore, learners knowing the appropriate meaning of the box and whisker diagram needed to draw it using the five number summary and comment on the points scored by players (question 1.4).

The cognitive level for question 2 was "routine procedures" in the SAGM taxonomy and the question weighted 20%. Here problems are not necessarily unfamiliar and can involve, the integration of different leaning outcomes, performing well-known procedures, simple applications and calculations which must have many steps and may require interpretation from given information, identifying and manipulating of formulae. In this question the data were listed, learners were asked to calculate the mean (question 2.1), the standard deviation (question 2.2) for the data, and to find how many scores lie outside on standard deviation the mean (question 2.3). Learners needed to use well-kwon procedures to calculate the mean (question 2.1). They also needed to use simple applications and calculations which must have many steps and may require interpretation from given information to calculate the standard deviation (question 2.2). Finally, in question 2.3, learners needed to interpret the data to find that 2 golfers' scores lie outside one standard deviation of the mean, showing that the interval for one standard deviation is (69.72;75.28).

Question 3 weighted 20% and categorised as "solving problems" in the SAGM taxonomy. At this level learners are involve in solving non-routine unseen problems be based on real contexts

by demonstrating higher level of understanding and cognitive processes, Interpreting and extrapolating from solutions obtained by solving problems based in unfamiliar contexts. In this question data was represented in the scatter plot. Learners were asked what is the lowest test score (question 3.1); does the data display a linear, quadratic or exponential relationship (question 3.2)? Justify your choice. What conclusion can be reached about the learners' test scores and the average number of hours they spend watching TV (question 3.3). In question 3.4, 'another learner from the class watches 35 hours of TV per week. Using the given information, predict his/her performance in the test' (question 3.4). In question 3.1 and 3.2 learners needed to solve problems based on real contexts by demonstrating higher level of understanding and cognitive processes. Question 3.3 and 3.4 needed learners interpreting and extrapolating from the data represented in the scatter plot. In question 3.3 learners needed to find that the greater the numbers of hours spent watching TV the lower the test scores and in the question 3.4, learners needed to predict his/her performance in the test was 60 marks.

Question 4 weighted 30%. The cognitive level for question 3 was "complex procedure" in SAGM taxonomy. In this level problems are mainly unfamiliar and learners are expected to solve by integrating different learning outcomes. Problems do not have a direct route to the solution but involve: using higher level calculation skills and reasoning to solve problems and Mathematical reasoning processes. In question 4 the data was shown in the frequency table. Learners were asked to construct a cumulative frequency table (question 4.1) and to draw a cumulative frequency graph (question 4.2). In question 4.3, learners were asked to estimate the percentage of 'gifted learners' in this group. 'If a learner answers the question correctly in less than 4 minutes, then he/she is classified as a gifted learner'. In question 4.1 and 4.2 learners needed to solve by integrating different learning outcomes, using higher level calculation skills and reasoning to solve problems. Here, learners in question 4.1 needed to complete the cumulative frequency table by calculating the cumulative values. Further, in question 4.2, learners needed to use the data from the cumulative frequency table to draw a cumulative frequency graph (ogive) representing the cumulative frequency against the time. In question 4.3, learners needed to use higher level Mathematical reasoning processes to estimate that approximately five learners or 16,67% were 'gifted learners' in this group.

It is interesting to note that in the 2010 and 2011 grade 12 Mathematics examination papers the question were assessed according to SAGM taxonomy using all the four categories of cognitive

levels. The weighting of the both, the 2010 and 2011 grade 12 Mathematics examination papers was in line with the approximate proportion of the Statistics questions in each paper as mention in the Subject Assessment Guideline for Mathematics.

Analysis of the statistical literacy, reasoning and thinking in the 2010 and 2011 Grade 12 Mathematics examination papers

The 2010 and 2011 Grade 12 Mathematics examination papers consisted of four Statistics questions each. Statistical concepts such as median, mean, five number summary, cumulative frequency, standard deviation, correlation scatter plot, ogive, and box-whisker were incorporated in all the questions in the two Mathematics examination papers. Furthermore, to examine statistical literacy, reasoning and thinking in the two examination papers, Statistics questions were numbered starting from the 2010 up to the 2011 examination papers. Words (coding units) that provide orientations requiring learners to demonstrate or develop an understanding in statistical literacy, reasoning and thinking were identified in the 2010 and 2011 Grade 12 Mathematics examination papers. These words were grouped into categories involving statistical literacy, reasoning and thinking. In the 2010 examination paper, 30.77% of Statistics questions assessed statistical literacy compared to 21.43% in the 2011 examination paper. In the 2010 examination paper, 53.85% of Statistics questions tested statistical reasoning compared to 57.14% in the 2011 examination paper. In the 2010 examination paper, 15.38% of Statistics questions tested statistical thinking compared to 21.43% in the 2011 examination paper.

It is evident from the above discussion that, in the 2010 and 2011 examination papers, statistical literacy, reasoning, and thinking were all assessed, with the statistical reasoning being the most assessed statistical learning outcome compare to statistical literacy and thinking. Furthermore, the four cognitive levels, knowledge, routine procedures, complex procedures and solving problem appeared in the 2010 and 2011 examination papers.

DISCUSSION OF FINDINGS

The literature identified three desired learning outcomes in the teaching of Statistics, namely statistical literacy, reasoning, and thinking. According to the literature the teaching of Statistics must develop statistical literacy, reasoning and thinking. These three statistical learning outcomes also appeared in The National Curriculum Statement in South Africa (DOE, 2003),

where learners must be able to: collect and use data to establish basic statistical and probability models, solve related problems, and critically consider representations provided or conclusions reached; solve non-routine, unseen problems using mathematical principles and processes; investigate historical aspects of the development and use of Mathematics in various cultures; and use available technology (the minimum being a modern scientific calculator) in calculations and in the development of models. To demonstrate or develop an understanding in statistical literacy, reasoning and thinking, words (verbs) that provide orientations (delMas, 2002) are use in writing assessment in Statistics. This is supported in the NCS (2008, 2011) document that used those words (verbs) to achieve the learning outcomes in the teaching of statistics. If a learning outcome is to develop statistical literacy, learners are asked to identify, to rephrase or translate statistical findings or interpret the results of a statistical procedure. To develop their statistical reasoning leaning outcome, learners are asked to explain why or how results were produced or why a conclusion is justified. Furthermore, if the outcome is to develop statistical thinking, learners are asked to apply, to critique and evaluate the design and conclusions of studies, or to generalise knowledge obtained from classroom examples.

The SAGM taxonomy (NCS, 2011) includes four cognitive levels, knowledge, routine procedures, complex procedures and solving problems. Smith, Wood, Coupland, Stephenson, Crawford and Ball (1996), assert that the Mathematics taxonomy assists with the structuring of examination questions that assess a range of skills and knowledge. Statistics being part of the Mathematics curriculum, these four cognitive levels in the SAGM taxonomy are used to assess a range of skills and knowledge. From the literature study and Subject Assessment Guidelines Document for Mathematics, assessment in Statistics should involve these four cognitive levels and develop statistical literacy, reasoning and thinking.

The qualitative data analysis consisted of the results of document analyses of the 2010 and 2011 grade 12 Mathematics examination papers**.** The analysis of the 2010 and 2011 examination papers revealed that the three statistical learning outcomes, statistical literacy, reasoning and thinking were assessed in these two examination papers. Furthermore the SAGM taxonomy was used in the two examination papers and the four cognitive levels were ordered by the nature of the questions. There were four questions in each paper and each question involved only one level of cognitive demand. The levels of complexity of the Statistics questions in the two examination papers were in line with the taxonomical categories.

LIMITATIONS

There are several limitations in this study. First, only two grade 12 examination papers were considered. Secondly, although most teachers were trained in Mathematics and Statistics but teachers might interpret the SAGM taxonomy cognitive levels and the SLO differently this might yield different results.

Despite these limitations, this study provides insights into the use of the SAGM taxonomy cognitive levels (knowledge, routine procedures, complex procedures and solving problems) in developing the statistical learning outcomes (statistical literacy, reasoning and thinking) in writing assessment in Statistics.

CONCLUSION

The present study demonstrates that the Subject Assessment Guidelines for Mathematics taxonomy should be used in developing statistical literacy, reasoning and thinking. Further, this study shows that both, the SAGM taxonomy and the SLO cannot be used without involving each other in writing assessment. The SAGM taxonomy helps to classify assessment tasks into different levels of complexity and statistical literacy, reasoning and thinking distinguish between desired learning outcomes in Statistics. Both, the SAGM taxonomy and SLO are helpful in writing assessment. This was confirmed by the literature and qualitative analysis of 2010 and 2011 grade 12 Mathematics examination papers.

RECOMMENDATIONS

Future intervention to improve the teaching of Statistics in South Africa should focus on training teachers in using the Subject Assessment Guidelines for Mathematics taxonomy in writing assessments. Furthermore, in the process of writing these assessments teachers should use words or verbs that provide orientations requiring learners to demonstrate or develop an understanding in statistical literacy, reasoning and thinking.

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