PRINT: ISSN 0975-1122 ONLINE: 2456-6322
Int J Edu Sci, 9(3): 351-360 (2015)
DOI: 10.31901/24566322.2015/09.03.12

The Use of Mathematics Taxonomy in Developing Statistical Learning Outcomes for Grade 12 Learners

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KEYWORDS Mathematics Cognitive Levels. Statistical Cognitive Outcomes

ABSTRACT In this paper the use of Mathematics taxonomy in developing statistical learning outcomes (SLO) for Grade 12 learners is investigated. A literature on Mathematics taxonomy and the SLO was reviewed. Further, a case was made for using the Mathematics taxonomy and the SLO in writing assessment tasks in teaching statistics. It is argued that Mathematics taxonomy uses four cognitive levels, knowledge, routine procedures, complex procedures and solving problem to guide all the assessment tasks. 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 examine the use of Mathematics taxonomy in developing the SLO. Results showed that the Mathematics taxonomy should be used in developing statistical literacy, reasoning and thinking. Mathematics teachers should be trained to usethe Mathematics taxonomy and the SLO in statistics assessment tasks.

INTRODUCTION

The National Curriculum Statement in South Africa includes Statistics in Further Education and Training (FET) Mathematics Curriculum (Department of Education (DoE) 2003; 2005).The National Department of Basic Education published the Mathematics taxonomy designed for use in constructing and assessing Mathematics (DoE 2007, 2008).The Mathematics taxonomy merges cognitive levels with the type of mathematics activities.

Teaching Statistics as part of the FET Mathematics curriculum requires the use of the Mathematics 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 and 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 Mathematics taxonomy in designing assessment tasks in Statistics suggests 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 emphasised 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 by the National Council of Teachers of Mathematics (NCTM 2000). In New Zealand, the school curriculum implicitly supports new instructional approaches to statistics and emphasises the changes needed in the pedagogy, 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 Curriculum Assessment Policy Statement (CAPS) document for teaching Mathematics and Statistics. According to the National Curriculum Statement (NCS) teachers should use available opportunity to hone their assessment skills in Mathematics (DoE 2008). These assessment skills relate both to the setting and marking of assessment tasks. Assessments should cater for a range of cognitive levels and abilities of learners (DoE 2011:53). A challenge for South Africa is when writing assessment in Statistics, the Mathematics taxonomy and the SLO should be kept in mind. One cannot be part of writing the assessment without involving the other.

In this paper the authors consider the use of the Mathematics taxonomy in developing statistical literacy, reasoning and thinking in writing assessment tasks in statistics.

Objectives of the Paper

The current paper sought to investigate the use of the Mathematics taxonomy in developing statistical literacy, reasoning and thinking. Furthermore, the authors would like to know if the four levels of cognitive demand for Mathematics taxonomy (knowledge, routine procedures, complex procedures and solving problems) can be used without involving SLO and vice-versa. The answers to this investigation are related to how the literature elaborates on SLO and on Mathematics taxonomy, and also to the results of the qualitative analysis of 2010 and 2011 Grade 12 Mathematics examination papers.

The paper was guided by the following research questions:

- Can the Mathematics taxonomy be used in developing statistical literacy, reasoning and thinking in writing assessment?
- Can the Mathematics taxonomy be used without involving the SLO in writing assessment?
- Can the SLO be used without involving the Mathematics taxonomy in writing assessment?

Literature Review

In this paper the literature reviewed the Mathematics taxonomy and the statistical learning outcomes concept. The learning outcomes are defined as the end product of a learning process by the South African Universities' Vice-Chancellors' Association (SUVCA 2000). Learning outcomes are statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence in the Official Journal of the European Union (OJ EU 2008). In the process of determining the learning outcomes one should ensure that all six levels of Bloom's taxonomy of cognitive skills are considered (Forehart 2005), levels of knowledge, comprehension, application, analysis, synthesis and evaluation.

In 1956, in his the publication of A Taxonomy of Cognitive Objectives, Benjamin Bloom talked about cognitive outcomes as learning outcomes which involve intellectual skills that could be classified in hierarchical form 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 skills that are characterised. From the above discussion it is clear that when writing assessment cognitive skills and/or actions should be kept in mind.

Mathematics Taxonomy

Within Mathematics, a number of different taxonomies have been developed for various purposes. In South Africa, the National Department of Basic Education published in the CAPS document four cognitive levels to guide all assessment tasks. The four cognitive levels are based on those suggested in the Trends in International Mathematics Science Study (TIMSS) paper of 1999 (DoE 2011; 53) and are listed asknowledge, routine procedures, complex procedures and solving problems. These four cognitive levels are ordered by the nature of the activity required to complete the assessment task successfully. The emphasise is that a Mathematics learner should be challenged to develop knowledge and skills. The descriptorsand guidelines percentage given for the distribution of marks for each level are summarised in the discussion that follows (DoE 2011: 53):

Knowledge (20%): This cognitive level involves straight recalling of previously learned information, 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 (35%): This cognitive level involves working with a learning material in a way that goes beyond a 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). A learner will have used the procedures in drill exercises prior to the assessment.

Complex Procedures (30%): This cognitive level 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 them by integrating different learning outcomes; the problems at this level do not have a direct route to the solution but could 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.

Problem Solving (15%): Learners should be able to solve 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 four cognitive levels can be used in Mathematics classrooms to complete the task successfully, this can also be the case in Statistics classrooms. According to the NCS the Mathematics taxonomy conflates cognitive levels with type of mathematical activity (DoE 2007). This assumption is also extended to the statistical activity where cognitive levels are used in writing assessment (DoE 2011: 48).The focus of assessment must be on external, observable actions on what learners can actually show that they can do (Donald et al. 2010:93).

Statistical Learning Outcome (Cognitive Outcome)

The discipline of Statistics is ideally suited to provide a wide variety of assessment opportunities (Bidgood and 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) conceptualises 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.

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 analysing 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 learning objectives could 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. Yet, there is no formal agreement regarding the definitions and distinctions of these terms. Although there is no formal agreement, the definitions used in the current paper are drawn from Chance et al. (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 paper.

Aspects of Chance et al.'s (2003) notion of statistical literacy, reasoning and thinking have been incorporated in The NCS (DoE 2007:11) and The CAPS (DoE 2011) in South Africa. These 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 uses 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 prepare an assessment task or question, they must ensure that the task or question addresses an aspect of a particular outcome. delMas (2002) suggested a list of words that provide orientations requiring learners to demonstrate or develop an understanding in statistical literacy, reasoning and thinking. 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. According to 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.

These words (verbs) could also be identified in the NCS and the CAPS (DoE 2008, 2011) documents where examples of the types of questions that can be set for each of the four categories of mathematical demand are given. 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 Mathematics taxonomy 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 levelsare considered.

METHODOLOGY

Design and Method

The current paper used a qualitative document analysis to investigate the use of the Mathematics taxonomy in developing the SLO.

Data were qualitatively analysed using the 2010 and 2011 Grade 12 Mathematics examination questions from the second papers. The purpose of the qualitative analysis was to identify the statistical learning outcomes and cognitive levels involved in these two examination papers.

Sample and Sampling Techniques

The sample for the study consisted of the 2010 and 2011 Mathematics examination papers from the second papers selected using a convenience sampling techniques.

Research Instrument

In this paper documentary data collection method was followed.

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Procedure

Permission for the paper was granted by the Free State Department of Basic Education. The first author 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 cognitive levels of Mathematics 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 using 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.

RESULTS

Analysis of Mathematics 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 percent. The fact that learners have demonstrated that they know and use appropriate vocabulary, identify statistical concepts from data sheet, led to classifying the problem in question 1 as a "Knowledge" cognitive level. In question 1, learners were given data in table form representing class A and a 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 2010 examination and give reasons for their conclusion (question 1.3). In question 1.1, it was expected that it would be 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 than class A, the reason being half of the learners get above 60 percent. In this question the results from the box whisker diagram for in class B skewed more to the left then that of the box whisker diagram for class A.

Question 2 weighted 26.7 percent. In this question the facts that problems are mainly unfamiliar and learners are expected to solve them by integrating different learning outcomes, led to classifying this problem as a " complex procedures" cognitive level. Problems in this category do not have a direct route to the solution but involve: (1) using higher level calculation skills and reasoning to solve problems; and, (2) 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 percent or more for the examination (question 2.3). In question 2.1 and question 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. Furthermore, 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 percent or more for the examination.

The problem in question 3 weighted 23.3 percent and was classified as "routine procedures" cognitive level. Problems in this category 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 could use a calculator or a pen and paper method. Finally, learners were expected 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 percent and was categorised as "solving problems" level. At this level learners are involved in solving non-routine unseen problems 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 had to motivate their answer (question 4.2). Learners were asked 'does the data confirm the researcher'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 questions 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 being attributed to the weak negative correlation of $r = -0.2128075984$. In question 4.4, the problem required learners' interpretation and extrapolation from the data represented in the histogram. Learners needed to say Alpha, because Alpha is 70 percent on-time arrival and has least luggage loss.

In the 2011 Examination Paper

Question 1 weighted 30 percent and was categorised as "knowledge" level. The skills to be demonstrated by learners were; 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 table form and were asked to determine the median (question 1.1), the inter quartiles (question1.2), to draw the box and whisker (question 1.3) and finally to use the box and whisker diagram to comment (question 1.4). In this question were expected to identify the mean (question 1.1) and the quartiles (question 1.2) from the data in table form. Learners could determine the inter-quartile range knowing the appropriate meaning of inter-quartile range. Furthermore, learners were expected to know the appropriate meaning of the box and whisker diagram to draw the five number summary and comment on the points scored by players (question 1.4).

The cognitive level for question 2 was "routine procedures" and the question weighted 20 percent. Here problems are not necessarily unfamiliar and could 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 one standard deviation of 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 were expected 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 percent and was categorised as "solving problems" cognitive level. At this level learners are involved 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 were expected 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 the problem requiredlearners to find that the greater the numbers of hours spent watching TV the lower the test scores. In the question 3.4 learners needed to predict his/her performance in the test was 60 marks.

Question 4 weighted 30 percent.The cognitive level for question 3 was "complex procedure". 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 cumulativefrequency 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 percent 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 Mathematics taxonomy using all the four categories of cognitive levels. The weighting of Statistics questions in the 2010 and 2011 Grade 12 Mathematics examination papers was not correctly used as mention in the CAPS document 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 percent of Statistics questions assessed statistical literacy compared to 21.43 percent in the 2011 examination paper. In the 2010 examination paper, 53.85 percent of Statistics questions tested statistical reasoning compared to 57.14 percent in the 2011 examination paper. In the 2010 examination paper, 15.38 percent of Statistics questions tested statistical thinking compared to 21.43 percent 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

The focus in this study was to determine the use of four levels of Mathematics taxonomy in developing statistical literacy, reasoning and thinking. The literature identified three desired learning outcomes in the teaching of Statistics, namely statistical literacy, reasoning, and thinking (Ben- Zvi and Garfield 2004). These three statistical learning outcomes also appeared in the NCS and The CAPS (DoE 2003, 2011) documents for Mathematics in South Africa, 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 tasks in Statistics. This is supported in the NCS and CAPS (DoE 2007, 2011) documents 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 Mathematics taxonomy (DoE 2007, 2011) includes four cognitive levels, knowledge, routine procedures, complex procedures and solving problems. Statistics being part of the Mathematics curriculum, these four cognitive levels of Mathematics taxonomy are used to assess a range of skills and knowledge. The literature on SLO, the NCS and the CAPS documents for Mathematics, revealed that assessment in Statistics should involve these four cognitive levels and develop statistical literacy, reasoning and thinking.

The qualitative data 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, four cognitive levels were involved in the two examination papers. The four cognitive levels were ordered by the nature of the questions. Each examination paper consisted of four questions and each question involved only one level of cognitive demand. The data analysis of the two examination papers revealed that the cognitive levels of the Statistics questions were not in line with the taxonomical categories.

CONCLUSION

From the results of this study, it could be concluded that the present paper demonstrates that the Mathematics taxonomy should be used in developing statistical literacy, reasoning and thinking. Furthermore, this paper shows that both, the Mathematicstaxonomy and the SLO cannot be used without involving each other in writing assessment tasks. The Mathematics taxonomy helps to classify assessment tasks into different levels of complexity and statistical literacy, reasoning and thinking distinguish between desired learning outcomes in Statistics.

This was confirmed by the literature and qualitative analysis of 2010 and 2011 Grade 12 Mathematics examination papers.

RECOMMENDATIONS

Based on the discussion and conclusion of this paper, the following recommendations were made. Future intervention to improve the teaching of Statistics in South Africa should focus on training teachers in using the Mathematics taxonomy in writing assessments tasks. Furthermore, in the process of writing these assessments tasks teachers should use words or verbs that provide orientations requiring learners to demonstrate or develop an understanding in statistical literacy, reasoning and thinking.

LIMITATIONS

This paper has limitations. Firstly, only two Grade 12 examination papers were considered. Secondly, in South Africa, teachers were not adequately, if not trained at all in the teaching of statistics in high school mathematics. These teachers might interpret the Mathematics taxonomy and the SLO differently that might yield different results.

Despite these limitations, this paper could provide insights into the use of Mathematicstaxonomy levels (knowledge, routine procedures, complex procedures and solving problems) in developing the statistical learning outcomes (statistical literacy, reasoning and thinking) in writing assessment tasks in Statistics.

ACKNOWLEDGEMENTS

The authors would like to thank Prof Greg Alexanderand Dr Junior Maimane for his guidance and support during the preparation of this paper.

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