STATISTICS AT FOUNDATION SCHOOL LEVEL IN SOUTH AFRICA THE WAY FORWARD ®

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Historically, little or no statistics has been taught at schools in South Africa. This is about to change dramatically with the introduction of a new curriculum. The dilemma however, is that statistics will have to be taught by teachers who have had little or no training in statistics! The authors propose a plan, aimed at the foundation phase, to assist teachers to cope with the challenges of teaching statistics successfully. They emphasize that it is of cardinal importance that statistical training is developed according to the age of the learners, bearing in mind the mathematical tools that they have at their disposal at that time.

INTRODUCTION

South Africa is on the brink of major changes in the school mathematics syllabus with the introduction of a new curriculum (Curriculum 2005). This curriculum, with outcome based education as fundamental building block, recognizes the cross-curricular need for statistics literacy and data analysis skills as an anticipated outcome, resulting in a vast amount of statistical material being included from the foundational phase onwards.

As is the case in many parts of the world, South African school teachers have generally had little or no training in statistics. This lead to a joint project being undertaken between the University of Natal, Durban (South Africa) and the University of Rome "La Sapienza"(Italy) in order to assist South African teachers to cope with the statistics content of the new syllabus. Due to the importance of having a solid set of basic concepts to build upon from year to year, this paper will only deal with the foundation phase, even though the project covers the foundation (grades 1 to 3), intermediate (grades 4 to 6) and senior (grades 7 to 9) phases.

TOWARDS A STATISTICALLY LITERATE SOCIETY UTILISING STATISTICS AND MATHEMATICS

Statistics literacy offers an orderly process by which specific problems involving quantitative information gathering may be analyzed and solved. However, for statistics literacy to be achieved, not only is statistics needed but also appropriate mathematical skills. Statistics, aided by mathematics, not withstanding the diversity of the two fields, have much to jointly offer in the quest for statistics literacy of the learner. Every school curriculum strives to insure that children have the mathematical tools of sorting, counting, arranging, grouping, adding, subtracting, multiplying, dividing, working with fractions and percentages, coping with measurement problems, utilizing the Euclidean space, etc. On the other hand, statistical investigation offers the possibility to work with different types of characters, *qualitative* and *quantitative (discrete and continuous),* each with their own algebraic structure. The project proposal is to merge the mathematical tools learners have at their disposal at that time, with the different structures of characters that statistics may manipulate, and then evolving this from the foundation through to the senior phase. In this way it is possible to develop the logic of gaining information and of solving a problem in an orderly way, with the added bonus of demonstrating an application for mathematical concepts and tools that learners have.

Outcome 6 of the learning area Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS) of Curriculum 2005 for South Africa schools (DOE, 1997) states that learners must be able to use data from various contexts to make informed judgements. The motivation for the need of this outcome being that "the age of rapid information expansion and technology makes the ability to manage data and information an indispensable skill for every citizen…. Learners need to acquire these skills for critical encounter with information in order to make informed decisions." In short, Outcome 6 will lead to *statistics literacy* of the South African learner.

The assessment criteria of Outcome 6 of Curriculum 2005 consists of the following: identification of situations for investigation, collection of data, organisation of data, application of statistical tools, display of data, communication of findings, critical evaluation of findings and understanding of probability.

These assessment criteria officially recognise the fact that data is only meaningful if the situation, which gave rise to the need for the data, is known to the learner. The learner is initially confronted with a problem to be investigated and then the data is collected, analysed and interpreted – much more meaningful than showing the learner how to apply statistical techniques to a given set of data. The natural progression in the mentioned assessment criteria, particularly communication and critical evaluation of findings, is essential for creating a true understanding of basic statistical concepts.

Focussing mainly on *qualitative* data in the foundation phase, *discrete* data in the intermediate phase and *continuous data* in the senior phase is our recommendation as this will have the effect of gradually building up the statistical tools needed to achieve statistics literacy at the end of compulsory schooling whilst ensuring that statistics skills and mathematics abilities develop together harmoniously.

MOVING TOWARDS STATISTICS LITERACY: THE FOUNDATION PHASE

It must be stressed that it is vitally important to get the basic statistical principles firmly in place, to emphasize the need and use of principles taught and above all to be wary of common errors when making statistical statements. This has not been emphasized in any of the phases of Outcome 6 (MLMMS) of Curriculum 2005. The volume of the proposed content is far too high, particularly in the foundation phase, where the concepts of variance, probability and predictions over time should rather be left for a later phase as they are not suitable here. For the foundation phase we thus suggest that the assessment criteria, range statements and performance indicators as stated in Outcome 6 (MLMMS) of Curriculum 2005 are modified in order to utilize *qualitative* characters only (Appendix).

Literacy on statistics education of young children (Moore, 1997; Rossman, 1995; Scheaffer, 1998) has claimed that statistics teaching should be built around a problem solving approach, i.e. data to be collected as a result of a problem/question/statement to be analyzed. After all, data have no meaning when separated from their context. Children must consequently be part of the data collection process so that the display of the data, the analysis and the subsequent drawing of conclusions can be meaningful to them. A young child's natural curiosity about himself and his surroundings leads to a wealth of potential situations to be investigated.

Proposed Questions

A good way to start would be to excite learners curiosity about their class and to induce them to develop and complete a simple questionnaire pertinent to their own life (Lombardo, Ottaviani, & Pannone, 2001). The teacher would then facilitate the class to organise the collected information in a database, which could finally be represented in poster format. We now present an example of such a questionnaire, suitable to develop a set of activities aimed at covering the various range statements as mentioned in the Appendix. Questions posed may be answered either verbally or written. Proposed categories are mentioned in brackets.

(1) Are you a (boy/girl)?
(2) What is your date of birth? (day/month/year)
(3) Did you have breakfast this morning? (yes/no)
(4) What do you like best? (watching T.V./playing sport) Choose only one.
(5) What do you enjoy doing most at school? (mathematics/reading/drawing)
Choose only one.
(6) Which of the following do you like? (apple/banana/orange/pumpkin/carrots/beans)
More than one reply allowed.
(7) Which pets do you have? (dog/cat/fish/bird/snake/hamster or mouse/other pet/no pet)
More than one reply allowed.
(8) How did you come to school today? (car/walk/taxi/bus/train/other)
Only one reply allowed, i.e. predominant method of transport.

Proposed Activities

A set of activities, utilizing the data collected from a particular grade 3 class in Durban (South Africa), will be presented for demonstrational purposes.

Activity 1

(a) Are there more boys than girls (or vice versa) in this class today?

(b) How many more boys are there than girls (or vice versa) in this class today?

Even though young children will know very well whether there are more boys than girls in their class (or vice versa), it is a good place to start as the concept of drawing a tally table and then representing graphically will be new to them and will have more meaning since they knew the outcome before setting about the task. It is important to represent graphically in as many ways as possible at this early stage so that they can become familiar with the various types of graphical representations. They thus learn that the number of boys and the number of girls counted (frequency) can be visualised graphically and, in addition to this, that their difference may also be graphically displayed. They do not have the mathematical tools at their disposal to be able to draw pie graphs at this stage, but they may very well be introduced to the reading of a pie chart. It will also be the task of higher phase teachers to stress the effect of changes in scale to the visual impact when making comparisons between various graphical displays.

The data from proposed question (1) would be utilized to answer questions (a) and (b) in this activity. A tally table from which a simple distribution can be represented in table format (Table 1) needs to be constructed and a graphical display can be produced (Figure 1) after instructing students how to link each frequency to the length of a line.

Table1:
Children Present In A Grade 3 Class at a School in Durban on 22 March 2001 by Gender

Boys	Girls	Total
22	23	45

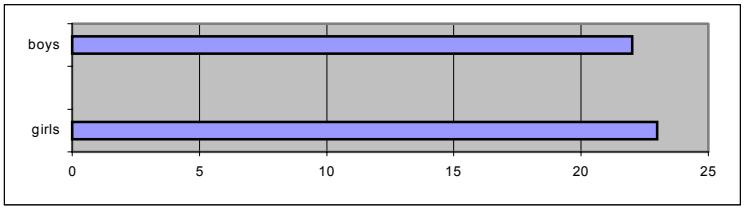

Figure 1. Children by Gender.

Questions (3), (4), (5), and (8) may be used similarly as follow-up exercises. The necessity of the words " this morning" in question (3) needs to be stressed as well as the making of a choice in questions (4) and (5). In question (8) the choice criteria is specified in the question.

Activity 2

(a) Do children from this class have birthdays equally spread throughout the months of the year?

(b) In which month (or months if a tie should occur) are the most children in this class born? And the least?

(c) How many children in this class have a birthday in May? Which months have an equal number of children with birthdays as in May? In which months do more children from this class have birthdays than in May?

(d) List the months of the year, corresponding to the lowest number of birthdays of children in this class, through to the highest.

(e) How many children in this class have birthdays in Winter (June, July, August)?

Question (a) initiates the idea that each category has its own frequency and that these values usually vary between categories. This is a key concept to which the very young child needs to be introduced, whilst questions (b), (c) and (d) are designed to reinforce the frequency concept. Question (e) leads to a situation where it makes sense to add frequencies, i.e. grouping categories

creates an opportunity to utilize a mathematical tool they have already learnt, addition. The class data collected from proposed question (2) would be used to draw up a tally table (Table 2) from which a simple bar chart (Figure 2) would be constructed for further visual analysis.

Table 2
Children by Birth Months

Month	Tally	Total
Jan	******	6
Feb	*	1
March	**	2
April	**	2
May	*****	5
June	****	4
July	**********	10
Aug	****	4
Sept	***	3
Oct	***	3
Nov	**	2
Dec	***	3

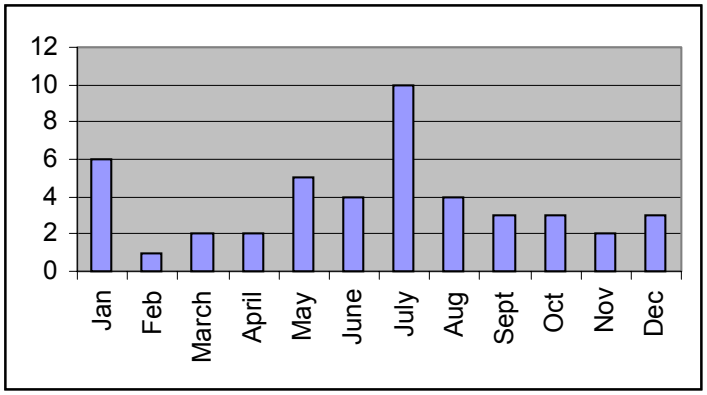

Figure 2.Children by Birth Months.

Activity 3 (Activity 1 as prerequisite in order for it to make sense)

(a) Do children from this class prefer beans to oranges?

(b) Do boys from this class prefer beans to oranges? What about girls?

This activity once again promotes an understanding of the key concepts of variation of the frequencies of categories. Question (b) develops the idea of subgrouping collected information, particularly by gender in this activity. This is to stress that the information obtained from the overall group may differ from the corresponding result for each of the subgroups.

A tally table and suitable bar charts need to be constructed for the data from proposed question (6) for each of the subgroups, boys and girls.

Table 3
Fruit and Vegetable Choices of Boys (Out of a Total of 22 Boys)

Fruit/Vegetable	Tally	Total
apple	***** ***** ***** ***** **	22
banana	***** ***** ***** ***** **	22
orange	***** ***** ***** ***	18
pumpkin	***** ***	8
carrot	***** ***** ***** ***	18
beans	***** ***** *****	15

A table for girls, similar to Table 3 for boys, and another one for the total of girls and boys can be constructed from which we would compile Table 4.

Table 4
Fruit and Vegetable Choices by Gender

Fruit or Vegetable	Number of boys (out of 22)	Number of girls (out of 23)	Total (out of 45)
apple	22	20	42
banana	22	17	39
orange	18	16	34
pumpkin	8	7	15
carrot	18	22	40
beans	15	20	35

Questions (a) and (b) from this activity can both be answered using Table 4, or alternatively, graphic displays may be utilised. We demonstrate in the case of question (b) where the subgrouping by gender comes into effect. A very important issue arises when comparing the heights of bars of two different graphical displays as in Graphs 3 and 4, in order to reply to instructions such as "compare the number of boys that like pumpkin with the number of girls that like pumpkin". It must be stressed that no comparison can be made between the bar heights for boys and those for girls liking a particular food mentioned, should there be a different number of boys and girls considered in the investigation. As the tool of division may be lacking in the foundation phase, this type of question cannot generally be answered by learners until the intermediate phase.

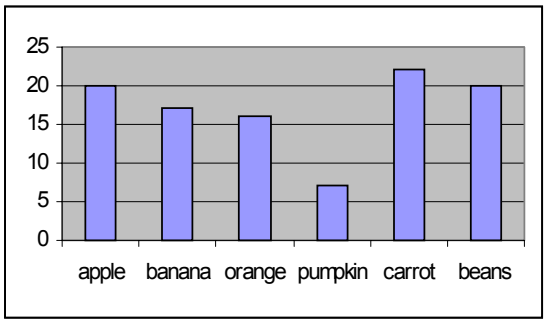

Figure 3. Fruit and Veg. Choices of Girls

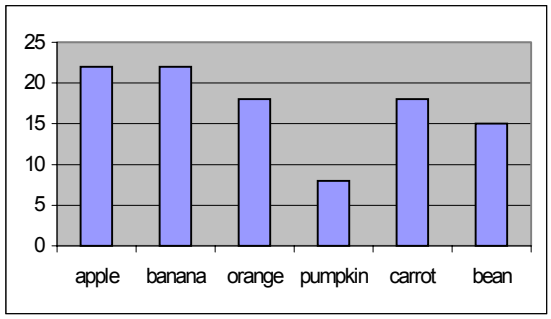

Figure 4. Fruit and Veg. Choices of Boys

The following type of question might very well come up during discussion in the classroom: "how many boys like beans *and* carrots". It is necessary to emphasize that in order to answer this question the original questionnaire replies, or better the database, needs to be consulted as the graphic displays and tables constructed to answer (b) are not useful now. This is due to fact that the categories are not mutually exclusive since each observational units may select any of a number of proposed options. Similar exercises can be devised from question (7).

CONCLUSIONS

Apart from didactic problems which may arise during the developing and divulging of the teaching of statistics at school level, it needs to be emphasised that statistics is not an isolated discipline, strange and separate from mathematics. In order for statistics to be successfully taught at school level, it is essential to show the teachers of mathematics the way to link mathematics and statistics. We suggest a gradual introduction to statistics, founded on the utilisation of mathematical concepts and tools learners already have, would be a way to demonstrate the value of statistics from a didactic point of view. The knowledge of statistics and mathematics, evolving together, in a harmonious way as proposed, would result in the acquisition of a skill indispensable to every citizen, statistics literacy.

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APPENDIX

Proposal for the foundation phase with statistics literacy as goal

ASSESSMENT CRITERIA	RANGE STATEMENT	PERFORMANCE INDICATORS
		This is evident when the learner*:*
1. Identify situations for investigation	Identify situations for collecting qualitative data	Identifies situations and the characteristics of the problem for data collection
2. Collection of data	Choose methods of data collection Interview (both verbal and written)	Asks appropriate questions to gather data for the situation being investigated. Pays particular attention to the necessity of each question. Clarifies each question very well, avoiding all doubt. Shows logical sequence in questions asked.
3. Organisation of data	List and arrange qualitative data in an appropriate way Sort relevant data Simple grouping of categories	Records data correctly (data base) Can extract and re-organise data to solve related problems
4. Display of data	Draw summary Represent data using tables, graphs and charts	Presents the data from the database in a simple table and in simple graphical form with a suitable title Gives clear and labelled charts about data Gives a verbal/written description of data Uses different instruments and constructions to display data and is aware of the difference between them
5. Application of statistical tools	Choose most suitable method. Show understanding of the concept of observational unit, qualitative variable, categories, frequencies. Notion of *variation* of frequencies between categories	Arranges frequencies in particular order and categories as a consequence. Comments on how often we have an occurrence Identify the most frequent category (mode)
6. Communica-tion of results	Show understanding of use of simple statistical language (oral and written)	Identifies trends of most/least popular category groupings in the data. Is aware of commonly made errors
7. Critical evaluation of findings	Explain meanings of information. Analyse validity and the impact of results	Discusses the possible reasons for the obtained representations. Discusses whether these results may change in time