Graphing in the Primary School:
Algorithm versus Comprehension

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Teaching;
Data

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Summary
This article examines the role of graphical work in data handling in the early years of schooling

◆INTRODUCTION◆

FOR the primary teacher the addition of statistics or, more accurately, the expansion of statistics in
the school curriculum provides another strain on an already crowded curriculum. Yet the need for an expansion of statistics education cannot be ignored. One only has to read a newspaper or government document to realise that a variety of statistical information is used as a means of communication. With the advent of computers and other associated technologies the use of statistics and, in particular, graphical displays is likely to increase.

Educational organisations have acknowledged the increasing significance of statistics in the curriculum. For example, this is reflected in the Australian Education Council's Statement for Australian Schools (1991), the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics* (1989) and in the current British National Curriculum where a significant component of the Mathematics Curriculum is directed towards "Data Handling".

In light of the pressure to expand statistics education, the question facing most primary teachers is not whether statistics should be included in the curriculum but rather how to utilise activities with a statistical component effectively within the elementary curriculum. For the primary teacher this is a major problem. As indicated previously the primary programme is already crowded. Furthermore, Hawkins (1993) has noted the relatively low level of statistical education of primary teachers which places an additional strain on any attempt to expand statistical education in the curriculum.

At this juncture the paper will focus on one component of statistics in the primary curriculum, namely, graphing. A major concern is that the learning of graphing could be reduced to algorithmic learning. Data (such as height), favourite television programme and so on, might be collected in a mechanical way. Students would then, for example, "plug" the information into a bar graph and answer the usual type questions, such as who is tallest, what is the most popular programme and a myriad of other factual or low-level interpretative questions (questions that can be answered directly from the data). An examination of many of the activities suggested for teachers reveals the danger of "algorithmic graphing". While drawing a graph and answering factual or low-level interpretative questions are components of developing graphical skills, these are not the only components. In fact, in terms of the ability to use graphs in problem~solving situations or to analyse critically data in newspapers, on television or in other documents, these are the least important components. The danger that these low-level activities will become the focus of graphical education is further exacerbated by primary teachers' limited experience with statistics.

There needs to be a framework established which enables the primary teacher to focus on the significant aspects of the topic. One aspect of graphicacy, the need for an overall conceptual framework for "integrating' the various types of graphical forms into a curriculum has been discussed by Rangecroft (1991 a, 1991 b). Such a framework is a necessary but not sufficient requirement for an effective programme. In developing the various components of graphicacy as outlined by Rangecroft there is still an inherent danger that what will be developed are the algorithmic aspects of both drawing an interpreting graphs. The question that needs investigating is, "what are those aspects of graphing that need specific emphasis?" The remainder of this article concentrate on three particular components that are key to comprehending graphing:

- the nature of data
- alternative representations
- prediction.

These should be stressed within a graphing activity in the primary school. It should be noted that these components are often **implicit** aspects of activities for secondary students, but the foundation should be laid early. Furthermore, they should be an explicit focus of a graphing activity at the primary level.

These three components are now explored and examples are included. In discussing these components it is not realistic to suggest that primary teachers annex another topic - graphing - to the curriculum. Rather, the teaching of graphing needs to be integrated within the current curriculum. There are many graphing activities that are currently undertaken by students, and these can be modified or expanded to help develop primary students' comprehension of graphs fully

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◆NATUREOF DATA ◆

Students should explore the assumptions underlying the classification of data and interpretation of the meaning of data.

What do we understand by the word data? There are many graphing activities that are currently used in primary schools that can lead to a discussion of the meaning of data. The activity that will be described in this article concerns the collection of data on pets. Animals are a topic of general interest to a majority of students, and when discussing animals the idea of pets often arises. In classes the author has visited a discussion of pets has been raised in a variety of contexts. For example. an announcement on the morning radio about a lost pet, a new pet to talk about or, as happened on one occasion, a dog walked into the classroom. Whatever the initial incident that leads to a discussion of pets, the situation provides a natural opportunity to discuss pets. Within the discussion one question is, "What pets do the students have?'' This question provides a starting point for the activity.

The following conversation took place when students were discussing drawing a graph about their pets. These students were about 7 years old and had some experience with pictographs. John looked very worried, and the teacher could see him nodding his head up and down as if he was trying to count. When asked what the problem was, the following conversation took place (these are **edited parts** of the conversations)

John: They keep moving?
Teacher: What keep moving?
John: The fish ... I can't count them?
Teacher: What can you do?
John: Guess?... I have lots of fish.
Jackie: You can count the fish together.
Teacher: Jackie, can you explain'?
Jackie: They are all one fish
John: That's not fair!

In another group the problem of fish was also causing a problem.
Sandy: Twenty fish.
Paul: Sure.
Sandy. I got them for my birthday.
Jean: That's too many pets.
Sandy: I've got 20 pets.
Jean: My two dogs are just as many pets - they're bigger
Sandy: Twenty is more than two.
Sue: But you've only got one tank.

Both these conversations deal with the problem of defining the concept of fish as a pet. From the teacher's perspective the issue of what constitutes a pet, per se, is not an important question. However, the debate provides an excellent opportunity to discuss the implications of any definition". What does the graph look like if each fish is considered an individual pet? What happens if one tank is the pet? How about students who have a cat plus kittens versus just a cat? If the students are allowed to design a graph using the alternative "definitions" they will look very different. But the data are the same? The students are starting to explore the importance of assumptions in comprehending the nature of data. Even if two students (or groups) select the same type of representation, depending on the "definition" of a pet the result will look very different. A pictograph in which each fish represents a pet is likely to look as if fish are far more popular than in a situation where the tank represents the pet. Through this exploration the students start to comprehend that the visual impact of a graph can depend on how they define the terms. In the primary grades one does not need to try to develop this in detail. What is important is that students realise that data may not be "clean". They start to realise the importance of alternative solutions.

This type of discussion is possible in many activities that are currently part of the primary programme.
When students are asked questions such as, "how large is your family?" it is clear that the definition of family is culturally dependent. This particular activity is discussed within the *Used Number* Series (1990). Some other "objects" that are involved in graphing that lead to the realisation that how you classify or collect data affect how it looks and can be interpreted are situations involving colour (are different shades different colours; can you agree whether something is pink or red, ...); shapes (are squares different from rectangles; are all triangles put together); birthdays (are they collected by day of week, month or season) and so on.
This experience develops an understanding of the nature of data and that how they are viewed affects

what interpretations can be made. It enables students to start to develop the ability to analyse data and realise that data cannot always be accepted without a critical examination.

◆ALTERNATIVE◆ REPRESENTATIONS

Students should discuss and explore the possibility of alternative representations of data.

Even when data are collected, students are often directed to a particular representation. For example, birthday graphs are often in bar-type form starting from January (on the left), height graphs are ordered in a bar graph from smallest to tallest, or data on how students travel to school is represented by a pictograph. This does not give the students an opportunity to explore the possibility of different representations.

Again, let me return to drawing a graph of pets. Once the data are collected the question of how to represent the information has to be faced. How can the pet information be represented? Do you represent the information by having a list of pets by a person s name? Do you just represent the pets? In a pictograph does the size of the picture matter (larger pictures for larger dogs)? How do you organise the data? These and other questions form part of an open discussion of representation.

This type of discussion is essential if the students are to learn that alternative representations give different "pictures" of the data. Figures 1-4 show examples of different pictorial/pictograph representations of part of a particular set of pet data. It should be noted that not all groups chose to use traditionally organised pictographs. The different organisations allow for a discussion of the nature of data (e.g. fish tank versus individual fish, whether different sized pictures matter) and representation of data (grouping versus different types of pictograph). By allowing different groups to choose their own representations it is possible to have a discussion in which they compare them. Is one graph better than another? which do you prefer? Which is easier to comprehend? Such questions are an essential component in developing an understanding of the nature of representations.

Figures 1-4 can be considered to be progressively more sophisticated representations. This is particularly evident in Figure 4, in that it uses the 'tank' to represent the pet rather than the individual fish.

Consider the situation where students are asked to draw a graph of peoples' heights. In a discussion about the graph, students indicated that it should run

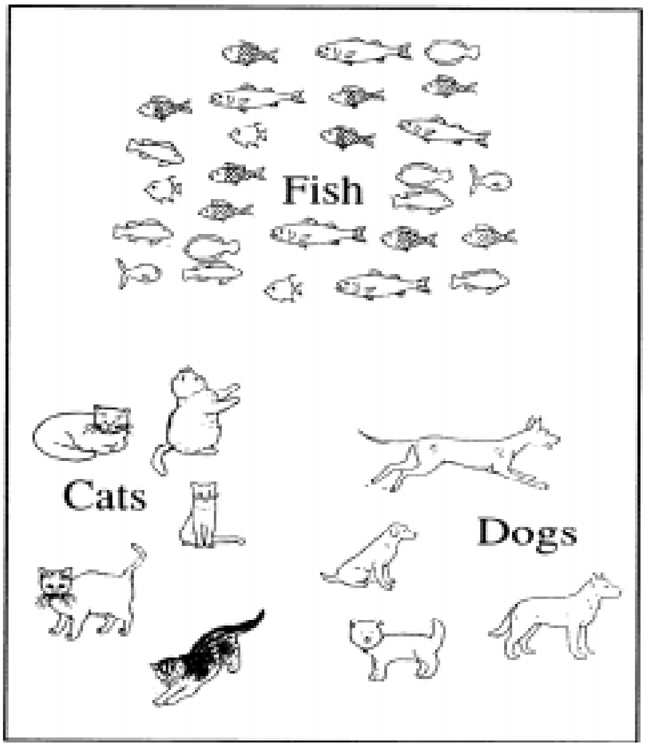

Fig. 1. Grouped Data - Different shapes and sizes for each pet.

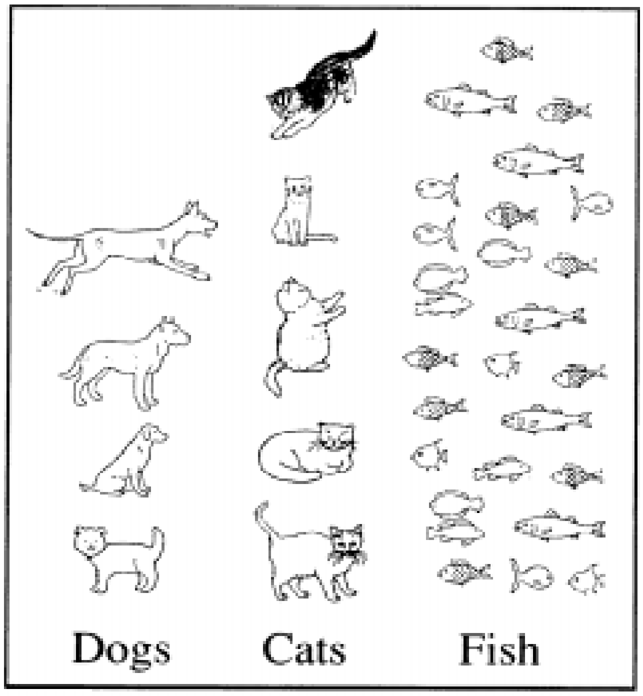

Fig. 2. Different shapes and sizes for each pet.

from either shortest to tallest or vice-versa. When asked if the data could be arranged in any order, they were unsure. In fact, in some situations students were unable to fit additional information into a graph. When presented

with a bar graph in which the heights were from shortest to tallest, when asked to fit in a person (whose height was around the "middle"), some students indicated that this could not be done because '~there was no room on

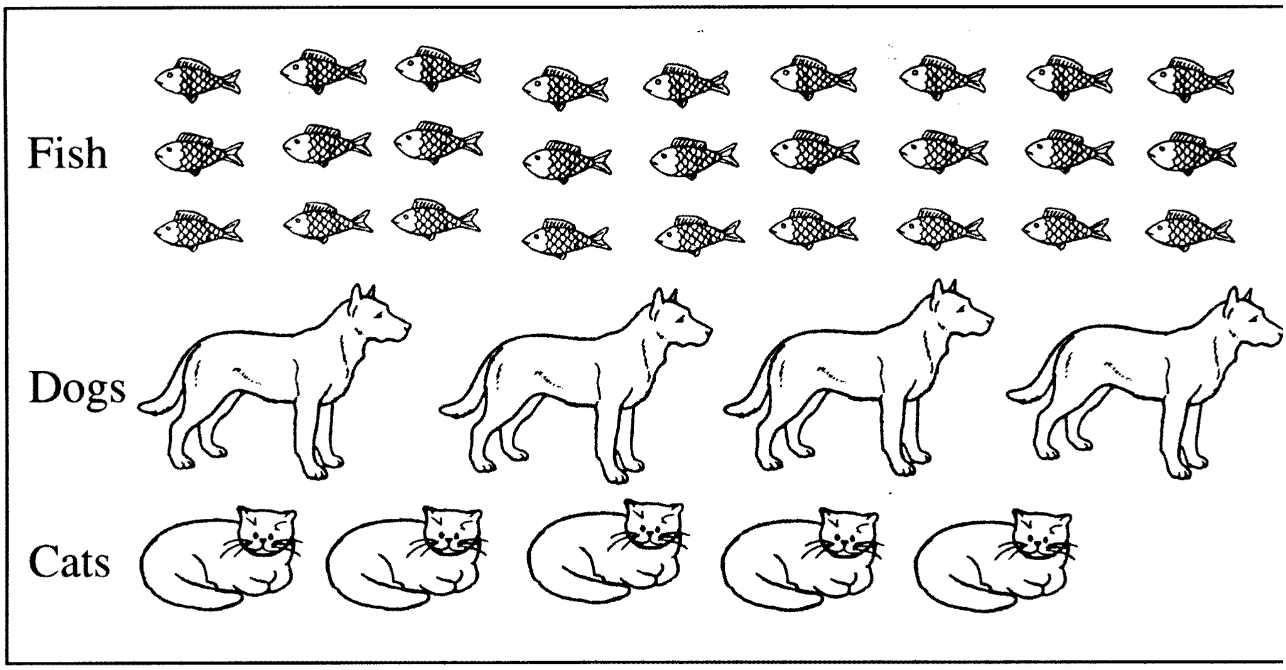

Fig. 3. Same shape and size within each pet type.

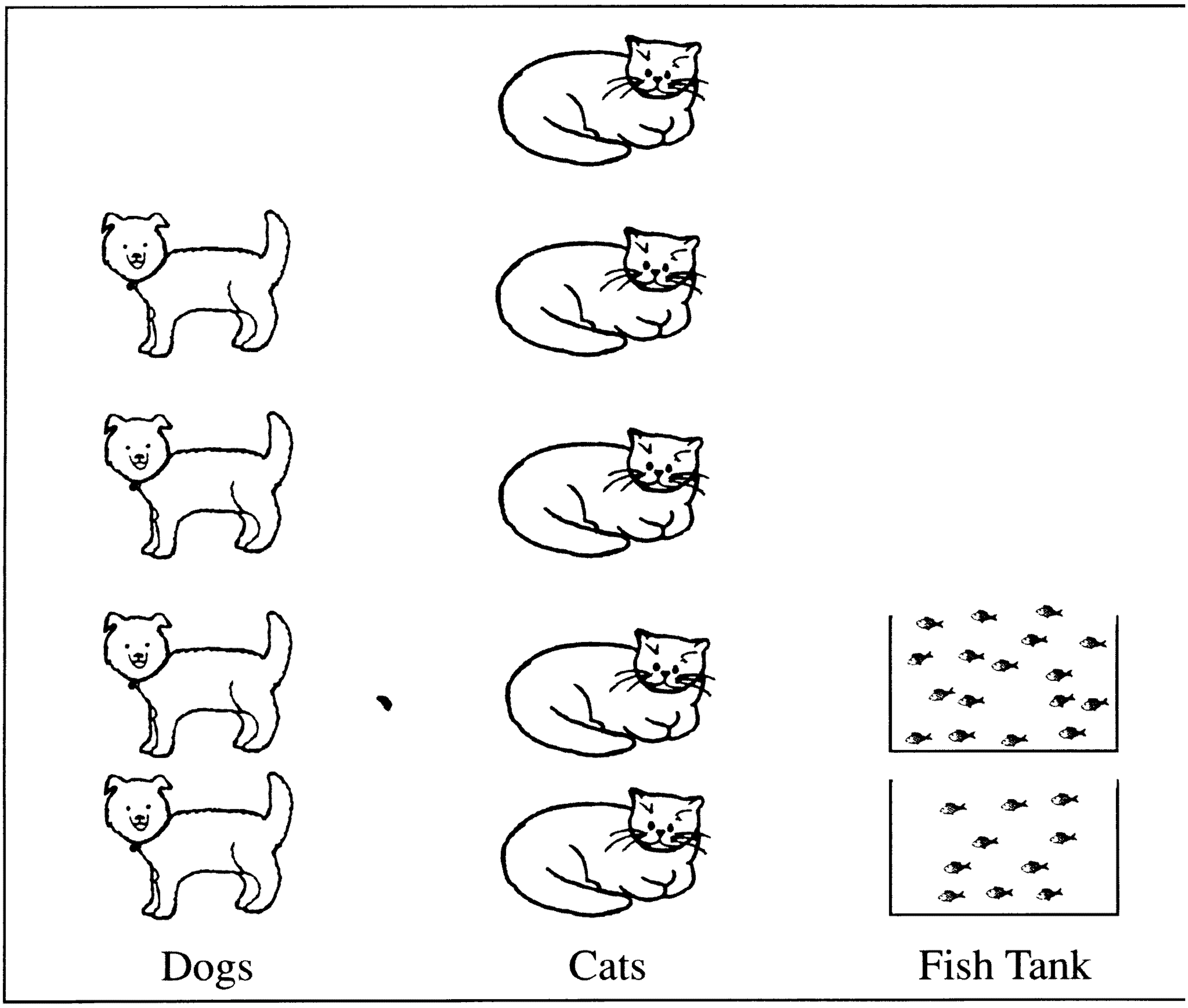

Fig. 4. Use of a fish tank instead of individual fish.

Note: Figures 1 - 4 contain stylized pictures. In the actual activity the students used cut-outs and photocop of the animals. However, these do not reproduce well.

the graph”

◆PREDICTION ◆

Students should predict from the data.

At the primary level many of the questions associated with graphs are interpretative. What is the most common pet? I-low many people travel by car? How many more children have black hair than blond hair? Such questions are important if one is to have a sense of what a graph means? However, these questions are also limited. In a situation where students were asked to interpret a graph of how children travel to school, they had little difficulty in interpreting the graph. When asked how a new child might travel to school they ignored the information provided by the graph and used their own “knowledge” (Pereira~Mendoza 1992). While students can interpret a graph they cannot utilise the graph to make realistic predictions or draw realistic implications. In a more recent discussion with students regarding M & M’s (candies) the students could draw a graph indicating the various colours in a package. However, when asked how many red candies there might be if they had two bags they would often guess. Even when asked if looking at the graph would help they would say no. This divorce between literal reading and interpreting, and predicting is, in part, a result of the types of questions we often ask primary students.

It is reasonable to speculate on whether young children should be asked prediction questions. The questions posed in the example that follows were successfully handled by many students. They were able to make reasonable suggestions. However, often students are not given the opportunity to explore questions that involve “going beyond the data”. If students are to develop skills in this area we should ask prediction questions starting with very young children. It is worth noting that although individual activities might involve prediction questions that students can answer, this is an area which needs research in order to understand better the extent to which prediction can reasonably be expected of young children.

Again, I will use the pets situation as an exemplar. Once the graph is designed there are two specific areas in which predictions can be explored:

(a) What pet might a child who was absent (or a new child) have?

(b) What would be the most popular pet in another class?

If there is a missing child the prediction can be tested against the real situation. Similarly, data can be collected from another class and compared. It is also possible to collect data from different grades to see if there is a difference. Within the context of the pets graph one of the most interesting questions was raised by a 10 year
old who wondered if the sex of the student mattered. Davies (1990) gives examples of some questions that provide such opportunities to explore.

◆CONCLUSION◆

By explicitly directing attention to the nature of data, alternative representations and prediction the focus of a graphing activity changes from the activity of drawing and tabulating data to underlying elements. These elements are critical in developing an understanding of what graphs mean and how they can be used in society. They help develop critical skills in analysing graphical information. If these elements are developed at the primary level, it will provide the necessary base on which secondary teachers can build. It also places the mechanics of graph drawing in their appropriate place, as subservient to the underlying conceptual schema that needs to be developed. Furthermore, this change in focus does not require a teacher to “go back to square one”. It suggests a change in orientation, in which the nature of data, alternative representations and prediction become a central, explicit focus of the curriculum, rather than, at best, an implicit focus of some activities.

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