PART 11

READINESS FOR ABSTRACTION

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Summary

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Abstract concepts are frequently represented by symbols or mathematical expressions, and until students are familiar with this technique of representation and have had practice in it they will find the process confusing and artificial. There is evidence that the process is difficult for children at all levels in the territory. One experiment asking children to make a map of their journey from home to school showed good sense of direction but little of specialised and selective representation that mapping entails.

Another experiment for identifying and recording the number of dots on a card with symmetrical arrangement (triangles, squares, hexagons) showed that the majority of children at all levels did recognise the advantage of using symmetry patterns over individual counting.

The third experiment required children to use an abstract strategy to pair 5 and then 6 colours. It seemed difficult for them to appreciate the function of a strategy as an abstract operation. It was observed that in every instance the children in urban areas performed better than those who lived away from the towns. This raised the question:
Are the particular examples and applications of science used in schools more familiar to urban children, and, further, would it be possible to develop science syllabi at primary and secondary levels which would be associated more closely with a rural setting in agriculture, forest or seashore settings?

Report

Introduction

During a visit to Papua New Guinea extending from April to September, 1971 an attempt has been made to assess the readiness of upper primary school children to make use of abstractions in understanding or representing real things. Experiments were carried out and information obtained in a number of schools distributed in several parts of the Territory. A full analysis of the data obtained will take some time, and their interpretation must await the collection of similar data from schools outside the Territory, in particular schools in Australia and the United States. While the conclusions stated here appear at present to be well founded, they remain open to revision during the course of further study.

Experimental Method

An important technique of science which often gives difficulty to beginning students is the use of abstract concepts to isolate specific attributes of a system or phenomenon,thus allowing the scientist to replace the real system with an idealization which is easier to understand. Abstract concepts are frequently represented by symbols or mathematical expressions. Until the student is familiar with this technique and has himself had practise in the use of symbols, he is likely to find the process confusing and artificial. It seems to lead away from the real phenomena into an artificial world of symbols and equations which of course he can memorize but which tend to lose connection with reality. There is considerable evidence that this process is a source of difficulty for Territory students at nearly all levels. The present investigation is an effort to learn how children in the upper primary levels use abstractions and hopefully to suggest ways in which they can obtain practice that will help to increase their skill.

An example of an abstraction or scientific model is a map. It represents a real geographical region yet it does so selectively, omitting much which would be confussing or unnecessary and reducing much of what is included to conventional symbols. A map is a very flexible kind of model which allows a given domain to be mapped in a great variety of ways depending upon the particular information that is to be represented. One of the experiments carried out here was to ask children to make a map to show "how you go from your house to the school." After the children had completed their maps the experimenter showed them some different sorts of maps, pointing out examples, which were usually present in the school room, of road maps, political maps, physical maps, etc.. Following this he explained another sort of map which could be used to represent a distribution or population density. He sketched an example of such a map on the blackboard to show how one could represent the distribution of pigs in and around a village. In doing this he made a point of using symbols instead of pictures and explicitly pointed out their advantage in saving time. A few days later the same children were asked to sketch maps of the school grounds showing where the children are likely to be found during recess. In this case the children were told in advance that their time would be limited so that their work was under some pressure of time.

Another experiment made use of a set of large flash cards on which dots are placed in sets of symmetrical arrangements (triangles, squares, or hexagons.) The children were asked to identify and record the total number of dots on a card which they were shown for long enough for easy identification of the symmetrical patterns but for too short a time to make it easy to count individual dots. From their recorded numbers one can distinguish whether they were identifying the patterns and using simple multiplication or whether they were trying to count individual spots. In addition one can measure the accuracy with which they multiply numbers ranging between 3x3 and 4 x 6.

A third experiment was used to see how easily children can understand and use an abstract strategy with which they are not previously acquainted. Using coloured chalks, five different colours were shown on the blackboard and several different pairs of colours indicated, (red and blue, green and blue, green and yellow, etcetera). The children were then asked how many different pairs is it possible to make using five colours. After they had taken time to think about this question and try out, usually at randon, various answers, a specific strategy was demonstrated which would easily determine the answer. The strategy was carried out in detail with each step demonstrated and explained. After this the children were asked how many different pairs it is possible to make using four colours. After they had given their answer the same strategy was demonstrated, again in detail, using four colours, and the children were then asked how many pairs it is possible to make using six colours.

Schools were selected in the Eastern Highlands and East Sepik Districts and in Port Moresby to include both urban and rural populations and to include some schools which have been using the new TPPS Primary Science Syllabus and some which were not yet using it. All testing was conducted in English and most of the tests were carried out in whole class groups in order to avoid difficulties due to the children's possible shyness in responding individually to a foreign visitor.

Results

The maps drawn to show the familiar route from home to school usually indicate a good sense of direction and very satisfactory skill in representing directional relationships. A few children failed to show directional relationships at all and a very few show them incorrectly, generally in the form of a mirror image. Nearly all of the maps are drawn using pictures of houses, trees, the school, etc with only a small minority using symbols other than recognizable pictures. Most of the maps include many unnecessary details put in for decoration, sometimes adding greatly to the attractiveness of the representation, but occasionally requiring so much time as to interfere with the actual objective of the map (for example when houses are drawn including all the detail of cesspit, roofing, etc.).

The maps which intend to show the distribution of children on the school grounds during recess usually fail to do so. Most commonly they show the school ground, again in pictures, and include pictures of a few children outside the classrooms, but usually too few are shown to give a concept of distribution. Not infrequently so much time was absorbed in drawing pictures of the buildings, trees, flowers, etc that there was not time left to show where the children would be. This in spite of the fact that the children were warned that their time would be limited, and again warned when their time was half gone. Some maps give a satisfactory representation by including very many pictures of children properly distributed and some, a small minority however, use symbols to represent a distribution in the manner that had been demonstrated to them earlier. A few include picture maps of the school ground and then describe the distribution in written words.

The experiment using flash cards indicates that at all levels a majority of the children recognize the advantage of using symmetry patterns over individual counting. This majority range from about 75% in some fourth standard classes to 100% in some sixth standard classes. In spite of this the number of errors in multiplication is very high, frequently more than 50% among fourth standard classes and often exceeding 30% among sixth standard. The error rate is rarely below 20% at any level. This is true in spite of the fact that the children were allowed as much time as they wished to arrive at their answers. Doubtless their accuracy would be considerably higher in a context limited to a lesson in oral arithmetic or recitation of the multiplication tables, but there would seem to be some question of their readiness to use multiplication apart from that context.

It proved to be very difficult for the children to appreciate the use or purpose of a strategy in the problem of pairing colours. All could understnad that the numbers of different pairs is limited, and all appeared to be very interested in finding the answer for any given number of colours but it seemed to be very difficult for them to appreciate the function of a strategy as an abstract operation that would work for any number of colours. Many were unable to use the strategy or understand its purpose even after three complete demonstrations, each time carried out in detail and fully explained. It would seem that the concept of a strategy as a procedure that could be carried out in abstract form and then applied generally was quite new to them. In many classes there were two or three children who were quick to follow the reasoning. However, these few stood out as isolated instances. Independent evidence from reading and from individual interviews suggests that the concept of a theory or strategy of understanding is absent or not well developed generally within the Territory peoples. This is a larger topic which should be treated separately, but the present experiment would seem to support that finding.

Discussion

Although the maps made by the children make very little use of symbols their excellent sense of direction and the skill with which pictures are executed suggests that it would only be a matter of practise and rather simple instruction for them to make excellent maps of a known route. It is natural for children to want to include everything that they can think of as possibly contributing to their representation. It is evident that they do get practise in drawing pictures, and it is obvious that they enjoy doing so, but there is very little evidence of the more specialized and selective representation that mapping entails. This is true even in schools using the new primary science syllabus. Exercises that involve classification or sorting, such as classification according to size, weight, etcetera, can easily lead to graphs which are first constructed physically by laying the classified objects in an appropriate array on the floor or on a table, and later the graph can be reproduced in symbols on paper. Within the context of lessons dealing with plants or animals, soil, or land forms, it would not be difficult to introduce some mapping exercises. These might start with very simple maps of the school ground or even of the school room in discussion of which a point is made of what is omitted from the map and why the omission of some real objects that are not themselves of interest makes the map easier to read. Further discussion and practise can show the way in which the use of some conventional symbols shortens the time required to make a map and renders it both more general and easier to read. A series of such exercises taken at appropriate times through the syllabus could finally lead to practise in much more sophisticated sorts of representation. Practise of this sort should serve an important role in developing skills that will be of great importance as the children later on become involved in more difficult and more abstract aspects of science.

The difficulty experienced by the children in trying to understand a strategy of pairing suggests the possibility of introducing puzzles once in a while or games of strategy as recreations which might tempt the children to use them at home or on the playground with their friends. An infrequent intervals, perhaps when one of these has caught the fancy of the children, it could be discussed within the classroom and the strategy involved worked out and illustrated. It might also be useful within the present science syllabus to make a point occasionally of the strategy of observation or explanation that is used. Why is it that certain things are observed and not others? After children have made certain observations they might be induced to consider which technique of explanation or representation will be most useful and then to see why this would be so.

In comparing observations taken at various schools with each other the most striking relationship is the contrast between urban and rural populations. In nearly every instance the children in the urban settings perform better and are quicker to learn than those who live some distance away from a town. In itself this is not very surprising. Even a moderate sized town provides a much wider variety of experiences and perhaps a greater complexity of relationships both physical and social. It is reasonable to expect that this would help to prepare the children for new ideas. In some cases also it may be that the urban schools have been there longer and are more closely integrated into the thinking of the community and of the children's parents. While it is easy to explain the observation in such terms, it does, nevertheless, raise some questions. Are the particular examples and applications of science used in the schools such as would be more familiar to urban children? Will this lead to greater success on the part of town and city children which in turn will further encourage the drift toward cities that is already present? It is possible that the manner in which science is taught as well as its technological implications are an important factor in producing an urban drift. This raises a further question as to whether, if it should be desirable, it would be possible to develop science syllabi at least at the primary and secondary school levels which would be associated more closely with a rural setting, making use of examples and applications primarily drawn from agricultural, forest or seashore settings.

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