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ABSTRACT

In order to name and classify a plant they see, children use their existing mental models to provide the plant with a name and classification. In this study, pupils of a range of ages (4,8,11 and 14 years old) were presented with preserved specimens of six different plants (strictly, five plants and a fungus) and asked a series of questions about them. The results indicated that pupils of all ages mainly recognize and use anatomical features when naming the plants and explaining why they are what they are. However, older pupils are more likely to also use habitat features. For both girls and boys, home and direct observation are more important as sources of knowledge than school, TV, videos, CD-ROMs or books, though, TV, videos, CD-ROMs and books seem more important for boys than for girls. As pupils age, their reasons for grouping plants become more complicated: in addition to relying on shared anatomical and habitat features, they begin to show evidence of a knowledge of taxonomy and use this knowledge to group plants. Contains 11 references and 9 tables. (Author)

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Building a Model of the Environment: How do Children See Plants?

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Building a Model of the Environment: How do Children See Plants?

Abstract

In order to name and classify a plant they see, children use their existing mental models to provide the plant with a name and classification. In this study pupils of a range of ages (4, 8, 11 and 14 years old) were presented with preserved specimens of six different plants (strictly, five plants and a fungus) and asked a series of questions about them. The results indicate that pupils of all ages mainly recognise and use anatomical features when naming the plants and explaining why they are what they are. However, older pupils are more likely to also use habitat features. For both girls and boys, the home and direct observation are more important as sources of knowledge than school, TV, videos, CD-ROMs or books, though TV, videos, CD-ROMs and books seem more important for boys than for girls. As pupils age, their reasons for grouping plants become more complicated: in addition to relying on shared anatomical and habitat features, they begin to show evidence of a knowledge of taxonomy and use this knowledge to group plants.

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Building a Model of the Environment: How do Children See Plants?

Introduction

We are interested in the way in which people build mental models, particularly models of the world about them and in the understanding school children have of the natural and physical environment. Mental models may be viewed as representations of an object or an event. and the process of forming and constructing models is a mental activity of an individual or group (Duit and Glynn, 1996). The mental model is the person's personal knowledge of the phenomenon - in the case of the present paper, of selected plants. This personal knowledge will have both similarities to and differences from scientifically accepted knowledge, which in the case of the present paper is such things as the taxonomic position of the plant, its significant morphological features and so on.

This paper is a companion one to Tunnicliffe and Reiss (1999) which reported our findings from an equivalent study on animals. In this study we asked pupils to name and categorise a selection of plants presented to them. Less work has been done on pupils' understandings of plants than of animals and what work has been done has mainly concentrated on pupils' understandings of such processes as growth and photosynthesis (Barker and Carr, 1989; Russell and Watt, 1990; Osborne, Wadsworth and Black, 1992). In addition, a considerable literature exists about children's understandings of the natural and physical environment (e.g. Strommen, 1995) and about the naming of plants (e.g. Brown, 1983; Plotkin, 1994).

Comparisons between different populations of children are complicated by the fact that a variety of methodologies have been used. We are keen to provide a methodology and a method of analysis which allows for such inter-population comparisons in addition to comparisons within a population between various pupil categories - e.g. gender and age.

In this paper, our particular aim is to explore how school children aged from five to fourteen years recognise, identify and group plants. Our foci are on the relationship between the children's personal knowledge and scientifically accepted knowledge and on the sources of the children's knowledge which they identify as being of importance to them.

Methods

Fieldwork was carried out in two state schools in the South of England: a Church of England aided primary school (for 5 to 11 year-olds) in a New Town (established after the Second World War) and a secondary comprehensive school (for 11 to 16 year-olds) in a long-established neighbouring town. The same researcher (SDT) carried out all the interviews. The fieldwork was conducted in a separate room (in the secondary school) or in the corner of a classroom (in the primary school). A total of 36 pupils (nine aged 5, nine aged 8, nine aged 10 and nine aged 14) were withdrawn individually from their regular work for the research. Teachers were asked to ensure that pupils of a range of abilities were interviewed (equal numbers at each age range classified by their teachers as 'above average', 'average' and 'below average').

After completing a pilot study, the six 'plants' (strictly, 'five plants and one fungus' but to avoid this rather long-winded phrase, 'six plants' is used throughout the paper) listed in table 1 were used. The mushroom was purchased from a supermarket, the fern from a plant nursery and the other specimens were dug up from the garden from one of the researchers.

Each pupil was shown a collection of the six plants. The pupil was first asked to put the plants into the order in which she/he would like to talk about them. This order was recorded and the researcher then presented the plants individually in this order. For each plant in turn the pupil was asked a series of questions about what the plant was (to which the pupil replied 'an X'), why they had named the plant thus and what made it an X. The pupils were then asked to group the plants, the researcher saying 'Would you group the plants for me, please? Do any of them belong together?'. Finally, they were asked to justify their choice of grouping.

Questions were asked according to a pre-set format (available from either of us for any interested readers) and prompts used as needed. Pupil answers, and any prompts given by the researcher, were written on observation sheets (also available from us) on which a record was also made of the name, age, sex and ability range (as defined by the teacher) of the pupil.

A rationale for the methodology is as follows:

- Use of live plants is more realistic than the use of drawings or photographs.
- Can be used with pupils / students of a wide range of ages (4 years upwards).
- Allows longitudinal study (e.g. each pupil can be interviewed every year) using either the same or different plants.
- Allows cross-sectional study using the same plants for different age groups.
- Allows other researchers to use the protocol (e.g. in other countries) without requiring audio/video-taping equipment. [Any researcher intending to use the approach described here is very welcome to send their pilot results to us for comment and evaluation.]

Results

The order in which pupils choose to talk about the plants

Pupils varied in the time and care they took in deciding the order in which they wished to talk about the plants. The first column of quantitative data in table 2 shows which plants were chosen first by pupils. On the assumption that plants are chosen first at random, the expected total number of first choices for each plant is 6. A chi-squared test on the data in table 2 gives $\chi^2 = 10.7$, 5 df, $0.05 < p < 0.1$ which suggests that plants are not chosen first at random. The Scots pine is chosen almost twice as often as chance would predict, the moss two times less often and the grass six times less often. A possible explanation for these findings is that the Scots pine was quite large (table 1) while the moss and grass are probably less obvious or interesting to pupils on account of their small size (particularly in the case of the moss), absence of bright flowers (compared to the daisy) and lack of utility (compared to the mushroom).

Table 2 also shows for each plant its mean position and a standard error of this mean (the second and third columns of quantitative data). Had a plant always been chosen first, its mean position would be 1.0. Had it been chosen randomly, its mean position would be 3.5. To see whether there are any significant differences between the mean positions of the six plants, a Tukey-Kramer test was used and values of q calculated for $k = 6$, $df = 210$. These show that none of the differences reach significance at the 5% level, though that between the Scots pine and the moss comes close ($q = 3.95$, with the critical value being 4.07).

Reasons given by pupils for naming plants as they did

For each plant, pupils were asked what its name was and why they had named it as they had. Overall 96% of the presented specimens ($n = 216$; 6 plants to each of 36 pupils) elicited a name (e.g. 'Fir cone bush' - for the Scots pine - and 'Mushroom') or category (e.g. 'Flower', 'House plant', 'Fungus' and, occasionally, 'Flowering plant'). The remaining 4% of presentations resulted in 'Don't know' or an equivalent.

The reasons given by pupils as to why they had named each plant as they had were categorised as 'Anatomy', 'Habitat', 'Function' or 'Form of plant'. For example, the following response by an 1 year-old girl presented with the daisy was categorised as 'Anatomy': 'The flower there - petals and middle bit'. The following response, by an 11 year-old boy to the moss, was categorised as 'Habitat': 'A marshy plant because it lives in mud'. The following response, by a 5 year-old girl to the fern, which she called a 'plant', was categorised as 'Function': 'Because it's growing and growing, it's getting bigger'. The following response, by a 14 year-old girl to the fern, was categorised as 'Form of plant': 'The way the leaves look, very tree-like, spread out'. Table 3 shows the number and percentage for each age class of responses. A total of 216 plant presentations were made but the total number of responses exceeds 216 as some pupil responses fell into two response categories.

Table 3 clearly indicates that when naming the specimens the great majority of pupils give anatomical reasons (79%) rather than reasons based on habitat (13%), function (4%) or the form of growth of the plant (4%). There is no significant evidence that different age groups differ in the reasons they use, though there is a hint that older (11 and 14 year-old) pupils were more likely to use habitat as a reason. This could be due either to younger children not knowing the habitats of certain of the plants or to habitat being considered as more important a reason by older pupils than by younger ones.

After a pupil had given a reason as to why the plant was an X (e.g. why the presented daisy was a buttercup if the pupil had named it a buttercup), the pupil was asked what it was about X that made it an X (e.g. 'What is it about it that makes it a buttercup?'). This was to investigate in more depth the attributes used by pupils when identifying plants. As before, responses were classified as 'Anatomy', 'Habitat', 'Function' or 'Form of plant'. These are recorded in table 4. Again, anatomical reasons predominate. However, reasons based on function seem to be more important than when simply explaining why an X is an X (table 3).

Although the sample size was small (18 girls; 18 boys), when responses were looked at by gender there was a suggestion that while girls were likely to give reasons that fell into just one category (e.g. 'Anatomy'), boys were more likely to give reasons that fell into more than one category (e.g. 'Anatomy' and 'Habitat').

The sources of pupil knowledge

Pupils who suggested a name for a plant were asked where they had learnt that name. The first row in table 5 shows the number of times pupils of different ages were able to state where they had learnt the name in question. Overall, 94% of the presented plants resulted in pupils being able to state where they had learnt the name in question. As one might expect, the 5 year-old children appear less able to do this (81%) than the 14 year-olds (98%).

Pupil responses were then categorised into 'From home', 'From school', 'From direct observation', 'From TV/video/CD/book' and 'Guessed'. The numbers of responses in these five (not mutually exclusive) categories are shown in table 5 as a function of the age of the pupil. Perhaps the most notable conclusion to draw from table 5, aside from the effects that age has, is the relative infrequency with which TVs, videos, CD-ROMs and books are mentioned as sources of knowledge. Overall the order of importance is: home, direct observation, school, TV/video/CD/books.

This conclusion is reinforced by table 6. Here, pupils were asked where they had learnt the attributes that they stated were necessary for category membership. For example, suppose a pupil stated that the male fern was an fern because of its leaves [fronds]. He or she would then be asked 'How do you know that?' and their answer categorised, as in table 5, into one of the five categories shown in table 6. Again, the results show that the most important source of learning is the home, followed by direct observation, followed by school, followed by TVs, videos, CD-ROMs and books.

Whilst sample size again makes discussion of gender differences speculative, there was evidence that boys are more likely to state that they have learnt from TVs, videos, CD-ROMs and books than are girls.

How pupils grouped the plants

The number of groups into which pupils of different ages grouped the plants is shown in table 7. Older pupils were more likely to group the plants into a small number of groups (e.g. a t-test comparing the mean number of groups for 5 and 14 year-olds gives $t = 2.52$, $df = 18$, $0.02 < p < 0.05$).

Pupils were asked their reasons for grouping the plants as they did and their classified responses are summarised in table 8. (Reasons that could not be classified into one of our categories are included under 'other', e.g. 'beauty' and 'because we eat them'.) Pupils of all ages were most likely to use reasons based on habitat or anatomical features. Older pupils were more likely than younger ones to use reasons based on taxonomy. They were less likely than younger pupils simply to state that some plants could not be grouped together because they were 'different' (classified as 'different' in table 8). There is no evidence that girls and boys differ in the reasons they give (table 9).

Discussion

When presented with a plant specimen and asked to name it and say what features it possesses which are salient to them in giving a name to the plant specimen, children have to recall their existing mental model of closest fit and match that to the plant they observe. Striking features such as the yellow centre of the daisy head with its white ray florets, the fronds of the fern and its smell, the leaves of the grass, the smell of the mushroom, the needle leaves of the pine tree and the green colour of the moss were important. Overall, parts of the anatomy of the plants were used significantly more than any other features or attributes when stating what the plants were and why they were that. Some pupils linked anatomical features to where the plants lived, particularly in the case of the moss, and to certain functions such as its need of water. Reasons based on habitat were also used fairly frequently. For example, mosses were said to be plants of wet places, as part of the child's rationale for naming.

School features little in pupils' recollections of their sources of learning, nor do TVs, videos, CD-ROMs and books. Instead, home is predominantly the source of knowledge coupled with pupils' direct observations out of school. These findings can perhaps be explained by the fact that plants are all around us. Indeed, all children will have touched 'wild' plants (e.g. grasses, daisies, trees) whereas many chilren will have never come into direct contact with any wild animals. On the other hand, compared to animals, plants star less often in children's books and cartoons. From a classroom teacher's point of view, school has a disappointingly low place in children's recollected learning about plants. Schools could, of course, play a far more significant role in this area, building upon the knowledge children acquire outside school.

Some of the possible gender differences are interesting though confident conclusions are not warranted given the relatively small sample size of 18 girls and 18 boys. When giving reasons for why they had named the specimens as they had, girls were likely to give reasons that fell into just one category (e.g. 'Anatomy'), whereas boys were more likely to give reasons that fell into more than one category (e.g. 'Anatomy' and 'Habitat'). When asked where they had learnt about the plants, boys appeared more likely than girls to state that they had learnt from TVs, videos, CD-ROMs and books. This fits in with the fairly widespread finding that whereas overall girls read more than boys, boys read non-fiction more than girls (e.g. Hall and Coles, 1997).

The need to classify that which one sees in front of one seems to be a fundamental human need (Bruner, Goodnow and Austin, 1956) - one that presumably evolved because of its adaptive significance. For example, the ability to classify plants as 'edible' or 'poisonous' would have had obvious advantages and, indeed, is not restricted to humans. Compared to younger children, older ones showed a greater variety of reasons for grouping the plants. In particular, they recognised the embedded knowledge of hierarchical taxonomies - e.g. they knew at least some of the reasons why a particular plant was a moss rather than a flowering plant.

Educational implications

Our work has educational implications both for formal science education settings (notably schools) and for informal ones (e.g. botanic gardens, museums, homes):

- Plants readily engage pupil interest. However, pupils tend to focus on striking anatomical features. Teachers (whether formal science teachers, botanic gardens educators or parents) can help pupils to learn by encouraging them to describe and comment on less obvious anatomical features. In other words, pupils can be helped to observe more carefully and with greater precision. For example, teachers could point out that fungi are not green, that mosses don't have flowers, that conifers often have thin needle-shaped leaves, etc..
- Few pupils link the anatomical features they observe to where plants live and to the adaptations they show. This may reflect the emphasis in much of biology teaching on naming and categorising organisms in isolation from their habitats and from other species. An alternative approach is for teachers to start with environments and their significant features and then explore with pupils how organisms in those environments are adapted anatomically to their particular habitats.
- Given that schools, TVs, videos, CD-ROMs and books may be less important as sources of knowledge than the home and direct observation, it is particularly worth teachers discussing with pupils their prior knowledge before attempting to teach them new material in this field.
- What emphases there are within science curricula on naming and classifying organisms may be at the expense of environmental understanding. As science educators, we need to teach pupils to become scientifically and environmental literate citizens (cf. Palmer, 1993). We don't want pupils to have a model of the environment simply as a background against which individual organisms stand. Rather, we want pupils to understand the ways in which plants and other species affect and are affected by their environments. We need to look at current emphases within school curricula. Alongside mental models of plants, pupils need mental models of a range of environments and an appreciation of how these environments meet the needs of the organisms that are adapted to live within them.

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Table 1 Specimens used in the study.

Common name	*Binomial name*	*Dimensions (two longest orthogonal axes in cm)*
Cultivated mushroom	*Agaricus bisporus*	6 x 5
Moss	*Funaria* sp.	3 x 2
Male fern	*Dryopteris filix-mas*	73 x 22
Scots pine	*Pinus sylvestris*	59 x 33
Daisy	*Bellis perennis*	13 x 9
Annual meadow-grass	*Poa annua*	16 x 15

Table 2 The number of times each plant was chosen first, the mean position in which each plant was chosen and the standard error of this mean.

Plant	*Number of times chosen first*	*Mean*	*Standard error of the mean*
Scots pine	11	2.83	0.29
Daisy	6	3.28	0.25
Annual meadow-grass	1	3.39	0.23
Male fern	8	3.69	0.31
Cultivated mushroom	7	3.83	0.32
Moss	3	3.94	0.26

Table 3 Reasons used by pupils for naming each specimen as they did.

Reasons used	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 254
Anatomy	41 (80%)	54 (87%)	54 (78%)	52 (72%)	201 (79%)
Habitat	6 (12%)	2 (3%)	12 (17%)	12 (17%)	32 (13%)
Function	4 (8%)	3 (5%)	1 (1%)	3 (4%)	11 (4%)
Form of plant	0 (0%)	3 (5%)	2 (8%)	5 (7%)	10 (4%)

Table 4 Reasons used by pupils as to why each specimen is what they said it is.

Reasons used	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 260
Anatomy	41 (79%)	54 (84%)	53 (83%)	51 (77%)	199 (77%)
Habitat	9 (17%)	4 (6%)	5 (8%)	11 (17%)	29 (11%)
Function	2 (4%)	3 (5%)	4 (6%)	9 (14%)	22 (8%)
Form of plant	0 (0%)	3 (5%)	2 (3%)	5 (8%)	10 (4%)

Table 5 The sources of learning of the names of the plants shown by age groups. For example, on 202 of the 216 occasions when a plant was presented, pupils were able to respond by naming at least one source from where they had learnt its name. On 71% of these 202 occasions, pupils named the home as a source of learning.

Whether name was learnt and where	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 216
Learnt name	44 (81%)	51 (94%)	54 (100%)	53 (98%)	202 (94%)
from home	30 (68%)	43 (84%)	35 (65%)	36 (68%)	144 (71%)
from school	8 (18%)	6 (12%)	22 (41%)	18 (34%)	54 (27%)
from direct observation	7 (16%)	20 (39%)	22 (41%)	17 (32%)	66 (33%)
from TV/video /CD/book	1 (2%)	6 (13%)	2 (4%)	1 (2%)	10 (5%)
Guessed	10 (23%)	3 (6%)	1 (2%)	1 (2%)	15 (7%)

Table 6 The sources of learning of the attributes necessary for category membership shown by age groups. For example, on 198 of the 216 occasions when a plant was presented, pupils were able to respond by naming at least one source from where they had learnt the attributes necessary for its category membership. On 64% of these 198 occasions, pupils named the home as a source of learning.

Whether attributes were learnt and where	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 216
Learnt attributes	41 (76%)	52 (96%)	54 (100%)	51 (94%)	198 (90%)
from home	27 (66%)	38 (73%)	31 (57%)	30 (59%)	126 (64%)
from school	5 (12%)	8 (15%)	22 (41%)	20 (39%)	55 (28%)
from direct observation	6 (15%)	17 (33%)	21 (39%)	16 (31%)	60 (30%)
from TV/video /CD/book	0 (0%)	7 (13%)	3 (6%)	1 (2%)	11 (6%)
Guessed	8 (20%)	2 (4%)	2 (4%)	0 (0%)	12 (6%)

Table 7 The number of groups into which pupils of different ages grouped the plants.

Number of pupils with this number of groups‡	5 years n = 10	8 years n = 11	10 years n = 9	14 years n = 10
1	0	0	0	0
2	1	1	2	3
3	2	4	0	1
4	2	6	7	4
5	3	0	1	2
6	2	0	0	0
Mean	4.3	3.45	3.7	3.5
Standard error	0.42	0.21	0.30	0.37

‡ Four pupils suggested two different ways in which the plants could be grouped.

Table 8 The reasons given by pupils for of different ages for grouping specimens. (Explanations of these reasons are given in the text.)

Reasons given for grouping	5 years	8 years	10 years	14 years	Total n = 90
Habitat	8	5	10	8	31
Anatomy	3	7	3	2	15
Taxonomy	0	0	3	5	8
Non-possession of a feature	0	3	1	1	5
Different	10	7	5	3	25
Other	1	1	1	3	6

Table 9 The reasons given by boys and girls for grouping specimens.

Reasons given for grouping	Girls' responses n = 48 n (%)	Boys' responses n = 52 n (%)
Habitat	16 (33)	15 (29)
Anatomy	7 (15)	8 (15)
Taxonomy	6 (13)	2 (4)
Non-possession of a feature	7 (15)	8 (15)
Different	11 (23)	14 (27)
Other	1 (2)	5 (10)

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