DOCUMENT RESUME

ED 436 423 SE 063 047

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TITLE The Development of Children's Ideas on Animal Classification, Form and Function; Is School Experience Becoming Increasingly Impoverished?
PUB DATE 1998-00-00
NOTE 13p.
PUB TYPE Reports - Research (143)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Animals; *Biological Sciences; *Classification; Elementary School Students; Elementary Secondary Education; Foreign Countries; Science Education; Secondary School Students

ABSTRACT

This paper begins with a review of previous research into children's classification schema, specifically with regard to the concept of vertebrate/invertebrate, before citing the details of more recent findings with primary aged children. This research explores the concept of vertebrate/invertebrate and how ideas progress across primary and secondary school. Reasons for the apparent lack of awareness of form and function in animals is considered before making some suggestions for improvements that could be made in the science curriculum for primary schools. (Contains 18 references.) (NB)

The Development of Children's Ideas on Animal Classification, Form and Function; Is School Experience Becoming Increasingly Impoverished?

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The development of children's ideas on animal classification, form and function; is school experience becoming increasingly impoverished ?

1. Introduction :

It has been known for some time that schoolchildren at all ages have problems with even simple classification tasks. In large scale surveys of performance used by the Assessment of Performance Unit in Science(APU), for example, it was found that mean scores for classification questions often lagged behind those in other areas of biology (Schofield *et. al.*, 1984). Typically questions asked children to group vertebrates, invertebrates and sub-groups such as fish, amphibians and reptiles from pictures and/or to relate characteristics to the various groups. Teachers have often noticed a tendency to ascribe generalised characteristics such as "worm-like" or "creepie-crawlie" to any animal associated with these attributes amongst younger children. More specific examination of children's ideas in relation to concepts such as vertebrate/invertebrate, however, seems to indicate a much more fundamental and worrying lack of awareness of form in relation to function.

This paper starts with a review of previous research into children's classification schema (mainly in relation to the concept of vertebrate/invertebrate) before citing the details of more recent findings with primary aged children. This research explored the concept of vertebrate/invertebrate and how ideas progress across the primary and secondary school. The discussion will then consider reasons for the apparent lack of awareness of form and function in animals before turning to some suggestions for improvements that could be made in the science curriculum for primary schools.

2. Previous relevant research findings:

Key studies carried out by Ryman (1974a, 1974b) asking children of secondary school age to group animals shown by line drawings into major vertebrate and

invertebrate taxa seem to indicate that the concept of vertebrate was being applied in a very restricted way to animals with distinct heads and limbs. Trowbridge and Mintzes (1985) showed that children are also likely to think that animals with definite outlines, as opposed to more amorphous, flattened shapes, are vertebrates.

Much of the work cited above was 'pre-constructivist' in the sense that children were not asked to justify their choices for grouping. In a study carried out with children aged 11-14 (Braund, 1991) children were asked not only to say why they thought various examples would be grouped according to their choices but also to give details of their perceived use for taxonomy. The children used in this study were also part of a national survey into profiles and progression carried out by the APU (Archenhold and Braund *et.al.*,1991) and so performance on classification tasks could also be compared with performance data on observation and tests of general ability (e.g NFER 'AH2/AH3 tests' - see Heim *et. al.*,1974). The key findings from this research were :

- 'Invertebrate' was often associated with animals having small bodies or with no legs and in many cases with an aquatic lifestyle.

- The sub-concepts of 'amphibian' and 'fish' were often used to describe lifestyle rather than applied in a true taxonomic sense.

- Terms such as 'insect' and 'creature' were used to describe animals with a creeping or crawling habit. (Trowbridge and Mintzes, *op. cit.* refer to this as a tendency to use 'grouping garbage cans').

- A more refined use of concepts in classification may be linked to a more general competence in observation.

- Some of the 'best' performances on classification tasks came from children who declared an out-of-school use for taxonomy.

At this stage it is worth considering the last of these findings in a little more detail as it has a direct bearing on research quoted later. ***Table 1***, below, shows the number of children responding in different ways to the question "When have you found grouping or classifying animals most useful?"

Table1:

	Response categories	Responses (% for each age group) 12	14	16
A	Ecology/fieldwork	4	20	16
B	Using keys	12	0	16
C	Answers in tests	12	15	16
D	Other school related	4	30	31
E	Hobby/outside interest	0	20	0

The interesting result here is for children at age 14 responding in category E. Analysis of performance data from the classification tasks revealed that these were all children who performed well in comparison to their peers. What was even more surprising was that these children performed well above expectations based on both APU and general ability test data for the whole year cohort. In other words we might assume that these children did particularly well because they had found a personal use for taxonomy and/or had gained some knowledge of animal form and function from their hobbies (e.g. birdwatching and fishing).

3. Children's ideas about vertebrates and invertebrates in the primary school

3.1 The findings of recent research :

Previously not much was known of children's ideas about vertebrates and invertebrates in the primary school nor about how ideas might progress/change with age. A study was set up during 1995/1996 with children drawn from

Y3,Y4,Y5 and Y6 in a primary school and from Y8 and Y10 in a nearby secondary school to which most children transfer at age 11.

The study design was based on the well established and relatively unobtrusive technique of 'interviewing about instances' (Osborne and Freyberg, 1985). Children were shown a series of colour photographs of animals in the order listed in ***table 2*** (shown below) and asked to say whether the animal would have a backbone. Children were encouraged to explain their reasoning and to talk about the animals at all stages. At the end of the questioning children were asked if they had any out-of-school interests or hobbies relating to 'animals or wildlife'. In a parallel study (Braund, 1996) children in the primary school were encouraged to draw any animals they thought might be vertebrates/invertebrates.

Table 2 :

	% of pupils in each year group correctly identifying examples shown					
	Y3	**Y4**	**Y5**	**Y6**	**Y8**	**Y10**
	n=14	n=19	n=17	n=14	n=25	n=26
Examples						
Elephant	87	95	94	100	100	100
Fish	13	58	41	21	68	77
Gerbil	73	79	82	79	100	100
Ant	87	84	71	93	100	85
Bird	53	74	94	86	96	96
Child	100	100	100	100	100	100
Seal	67	68	71	29	84	85
Spider	53	68	71	93	80	100
Tortoise	40	32	47	14	36	38
Snake	13	26	12	21	28	46

These data show that children had little difficulty recognising an elephant and gerbil as vertebrates but that younger children were less confident about birds.

Analysis of verbal responses shows that in this case older children are more aware of a backbone providing for the movement required by flight.

When it comes to the seal, fish and tortoise an improvement in recognition is followed by a sharp decline. It seems that, as far as vertebrates living in water are concerned, older children appreciate a greater variety of possible movements but seem to think that the up/down, side-to-side movements of swimming require a flexible body and that backbones are generally too rigid to allow for this. The decline for the turtle is explained by the increasing number of children who think that having a 'shell' precludes also having a backbone.

As in previous studies, the snake proves to be the most problematic example of a vertebrate as far as children are concerned. There seem to be two main attributes that children associate with being "snake-like". The first is the idea that a snake is too long or too thin to accommodate a backbone. The second is that snakes curl up and a backbone cannot allow this. Detailed analysis of the trends in frameworks with age (for a full description of these see Braund, 1998 in press) suggest that these ideas are some of the most persistent found and this suggests that careful design of teaching will be required to draw children away from them.

Before turning to overall trends in ideas it is worth noting that children who were most successful at associating the snake, seal or fish with the concepts of vertebrate, i.e. those who 'bucked the trend', often referred to some first or second hand knowledge of structure, for example :

"My dad and me found a dead fish's skeleton on the beach " (Y3)
"I've seen a picture of a snake in a book - it had a bone in it" (Y5)
"We went to a museum and saw inside a whale" (Y8)

This is another example of the influence of informal learning referred to earlier in this paper.

The data in table 2 reveal that children had less of a problem recognising invertebrates. An inspection of their reasoning, however, shows that this may be far from 'scientific'. Primary aged children, especially, seemed preoccupied with the outline shape of the body. The responses shown below are typical and occur frequently in each age cohort of the primary sample.

"The spider has two bits ... it(the backbone) can't fit in-between"
"The ant has a sort of zigzag shape ..."

Secondary aged children were more likely to generalise (e.g. *"the ant's an insect and they don't have backbones"*) or to consider that other means of support makes a backbone unnecessary (e.g. *"it's got lots of legs to hold it up ... so it doesn't need a backbone.*)

3.2 Trends in ideas with age

The responses given by children in the study have been analysed in terms of the key 'attributes' used to justify examples as either vertebrate or invertebrate. (Braund, 1998 *ibid.*). From this analysis a number of features appear that characterise each age and so give some view on progression. It has to be remembered that many of the frameworks are overlapping and not unique to each age group. ***Figures 1*** and ***2*** shown below show these basic trends for children in Y3-Y8.

Figure 1 : Progression in children's ideas about vertebrates

Children tend to justify animals as vertebrates if they have (are) ...

Y3 children	Y4 children	Y5 children	Y6 children	Y8 children
... hard bodies	.. space for a backbone	... a backbone for movement	.. . a backbone for movement	... a backbone for movement
..definite outlines	... an arched shape	... for support	..for support	.. for support
		... flexible bodies	... connected to limbs	... classed as mammals

Figure 2 : Progression in children's ideas about invertebrates

Children tend to justify animals as invertebrates if they have (are) ...

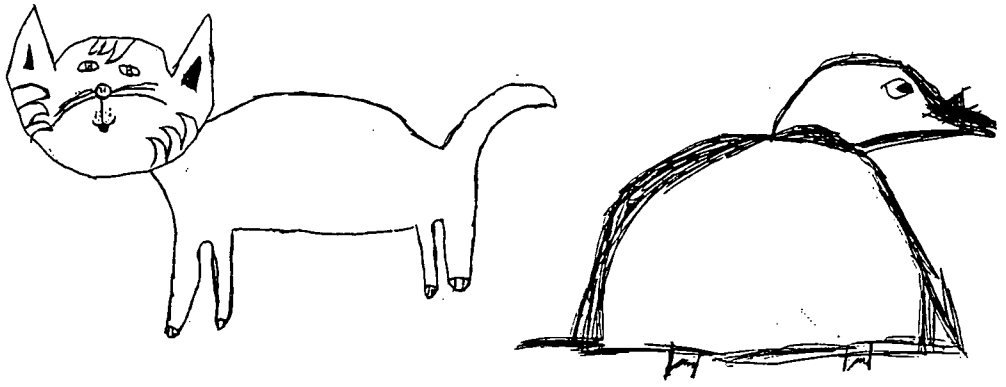
Y3 children	Y4 children	Y5 children	Y6 children	Y8 children
..soft bodies				
..crawling habits	..crawling habits			..crawling habits
..small bodies	..small bodies	..small bodies		
..thin shapes	..thin shapes	..thin shapes		
	..flexible bodies	..flexible bodies	..flexible bodies	..classed as
		.irregular outlines	.irregular outlines	invertebrates
				.have a flattened form.

The youngest children (Y3) tend to associate invertebrates with soft bodies and a small overall size. They are less preoccupied with the inherent flexibility of an invertebrate body.

The notion that shape and size indicates presence or absence of a backbone is quite persistent. As found in earlier studies (Trowbridge and Mintzes, Braund, *op. cit.*) the idea that vertebrates have an arched (strengthened?) shape seems to dominate. This notion is often represented in children's drawings of vertebrates (see Figure 3 below). Joel's drawing includes heavy pencil shading to emphasise curvature and talking with Joel revealed that this was his intent. In the parallel study of children's drawings (Braund, 1996 *op. cit.*) it was also found that most

children freely chose to draw a snake as their first choice for an invertebrate- few true invertebrates were in evidence!

Figure 3 : Examples of children's drawings of vertebrates



Lauren's drawing of a cat

Joel's drawing of a duck

Another important feature of children's responses was that they show that they may think of backbones as being very substantial structures i.e. too wide to fit inside animals like fish.

4. Implications for teaching - improving the experience of structure and function in the primary school

4.1. Sources of impoverished experience

One of the key messages from the research quoted in this paper must surely be that we should try to improve the quality of understanding that children have about the natural world and in particular how they relate the form of animals to their functioning. Children's experiences are becoming increasingly limited and this is partly due to cultural impact and partly to a narrowing of the school curriculum.

Cultural impact includes :

- the increasingly processed nature of food - "fish have fingers but rarely bones"

- anthropomorphism in cartoon animal characters e.g. bipedal/humanoid turtles (Teenage Mutant Ninja Turtles)
- erratic (increasingly middle class) use of museums as resources for learning (Anderson, 1997)

As far as the school curriculum is concerned there is little mention of skeletal functions at any Key Stage. Where mention is made, as in so many areas of biology, it is related to humans as if these are the sole representatives of the animal kingdom. Children's experience of 'real animals' in school has been on the decline for years as recent surveys show (see for example Lock and Millett, 1991; Reiss and Beaney, 1992).

Popular wildlife/zoological programming on television does not help the situation. Modern programmes tend to focus on behavioural and ecological aspects rather than on the structure and function of organisms. One series from the 1970s that managed successfully to bring together both elements was 'Animal Design' (Sparks/BBC, 1972). In both printed and moving image animals were shown so that internal structure could be related to movement.

The evidence quoted in this paper suggests that children's experiences are of quality and therefore help them to appreciate the ways in which organisms function as a result of home influences rather than teaching in school. The question then becomes one of whether we should accept this or whether we should try to enhance experiences for all. Recent research (Anderson, *op.cit.* page 60 *et. seq.*) in museum education seems to point to an inequitable situation where the children of the middle class are likely to benefit most from hands-on and interactive experience.

The most important question for curriculum developers, teachers and educators, therefore, must be how the quality of the school experience can be improved equitably. Since science is a relatively new area for primary school teachers and their own background knowledge in this area may well be weak (OfSTED, 1995)

this is also a question for these involved in initial and in-service training of teachers.

4.2 Strengthening children's experience

The research reported in this paper has shown that although children increasingly associate a backbone with movement they have problems in resolving this with flexibility. Primary aged children seem to think that backbones are big and stiff structures. Experiences must try to move children away from these notions and towards a wider appreciation of form and function.

This could start in the early years by using PE activities so that children can come to realise the flexibility of their own spinal column. Movement and exercise could be extended to simulate a variety of movements seen in the animal world; jumping, leaping, crawling etc. Children should be made aware of the need to keep their own backbones supple but not to overload them. Good posture and sensible lifting technique should be a part of the curriculum not least to help reduce the appalling rate of incidence of back problems seen in the UK today.

A milk straw used to model a backbone with a fishing line placed through it to act as a nerve cord will show that an inflexible structure will not allow for motion. If you remove the straw and cut it into separate pieces (vertebrae) and re-thread the nerve chord, you have movement - just like a snake! A good set of high quality diagrams and pictures in library books showing internal structures of animals would also help. Books in the Dorling Kindersley Eyewitness series (see for example, Page,1991) are an excellent example.

A flick-book of animal movement might help to simulate movement and at the same time show the internal flexing and articulation of the skeleton. Perhaps film-makers and software writers could collaborate here. I am sure that current

technology could be applied to generate some exciting and challenging learning materials.

Finally, but by no means an alternative, perhaps we should make it a priority to introduce children to many more examples of the 'real thing'. Regular contributors to the literature of biological education have called for more and better investigations with animals (Lock, 1993, Reiss, 1996). A common topic taught in the primary school is 'minibeasts'. Many of the activities here are aimed at classification, observation and/or habitat comparisons. I am not arguing that these foci should be replaced but that they could be enhanced by more work looking at the structures of jointed legs, segments and a muscular foot (in the case of molluscs). Such studies might help children to appreciate the many different ways in which movement is provided for in animals with strong external exoskeletons and shells, but lacking internal bones/backbones.

The moratorium on change promised with the 1995 revision of the National Curriculum is nearly over. Working groups are already preparing submissions on what they would like to see in a future primary science curriculum. Perhaps a little less quantity and a little more quality would not go amiss. The traditional danger of continuing simplification is that it produces a simplistic and impoverished diet rather than a rich and rewarding menu from which both teachers and learners can choose for healthy development. I hope a place can be found for a less anthropomorphic, animalistic and 'chordate dominated' curriculum in the future.

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