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ABSTRACT

This study examines what children learn about animals. The mental models that children reveal through their talk when they are faced with several different types of representations are reviewed. These representations are provided by robotic models in a museum, preserved animals in a museum, and preserved animals borrowed from a museum and presented in a school setting. The features of an animal, which are defining ones for a child, can be revealed by obtaining representations from the child of specimens that the child has viewed. These representations may be written descriptions, oral descriptions, drawings, or three-dimensional models. The museum study was conducted with groups of pupils on school visits to the Natural History Museum in London where the children's spontaneous conversations at preserved animal or robotic models were recorded. In the classroom study, preserved museum animals were taken to a school for individual children's responses to a series of pre-determined questions to be recorded. Overall, anatomical features were cited more often than behavioral or habitat features. Some pupils linked anatomical features to where the animals lived and to certain behaviors. In the classroom, pupils related their observations to their own previous experience such as seeing the animal in the woods, on the television, or in the zoo. The analyzed museum conversations suggest that children simply use their everyday knowledge and understanding to interpret what they see and to allocate everyday names using anatomical clues as their guide. (CCM)

What sense do children make of three-dimensional life-sized 'representations' of animals?

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What sense do children make of three-dimensional life-sized 'representations' of animals?

Children learn about animals in a whole variety of ways. Direct observations of wild animals, pets and farm animals can be important, while books, films and schools play significant roles. So too do zoos and museums which children have been visiting ever since these establishments opened their doors to the public.

Zoos are places where 'learning conversations' take place (Lucas, McManus, & Thomas, 1986). Many of these conversations are about animals (Tunnicliffe, 1995). Furthermore, parents state that they take their offspring to the zoo to "learn about animals" and to see or experience the "real animal" (Hill, 1971; Rosenfeld, 1980:39). In a zoo, a viewer does indeed see a 'real animal', albeit one that usually exists in an artificial setting without any prey, predators or other natural threats.

There are related reasons for taking children to natural history museums. To a large extent, visitors to museums let the exhibits set the agenda rather than bringing one with them (Hilke, 1988) but they interpret and talk about what they see through their own existing understanding (Tunnicliffe, Lucas, & Osborne, 1997). Indeed, museum animals can be of key importance for the zoological education of children (Tunnicliffe, 1996a).

In a museum, a visitor is confronted with three dimensional life-sized 'representations' of animals. Traditionally such representations consisted entirely of taxidermically preserved specimens. These animals are displayed so as to illustrate as faithfully as possible the external anatomical features of the living animal. Taxidermic specimens may also try to indicate certain behavioural features. For example, ducks may be shown in a small flock to imply sociality while a fox may be shown with a hare in its mouth to illustrate its predatory feeding habits.

More recently, certain museums have begun to provide robotic animals in their exhibits. Such exhibits can be popular with children but they differ in several crucial respects from living specimens (Tunnicliffe, 1996b). In particular, robotics move in a predictable and stereotypic fashion.

Museums rarely if ever lend robotics to teachers for classroom use but there has been a long history of teachers borrowing stuffed museum animals and using them in the classroom. When used in this way, a possible disadvantage is that the animals are removed from a professionally constructed naturalistic environment in the museum. Such environments are an integral part of certain museum exhibits and help create the opportunities for children to 'read' a more holistic story about the animal and its natural environment. On the other hand, the classroom teacher may be able through story and other pedagogic devices to provide a far richer imagined environment for the borrowed animal than it could ever inhabit in its silent museum setting.

Purpose of this study

We are interested in what children learn about animals. One way into this question is to examine the mental models that children reveal through their talk when they are faced with several different types of representations. In this study these representations are provided by (i) robotic models in a museum; (ii) preserved animals in a museum; (iii) preserved animals borrowed from a museum and presented in a school setting.

Mental models may be viewed as representations of an object or an event. The process of forming and constructing models is a mental activity of an individual or group (Duit & Glynn, 1996). A mental model is an individual's personal knowledge of a phenomenon - in this case, of animals. The personal knowledge of the viewer faced with a representation of an animal will have both similarities to and differences from scientifically accepted knowledge, namely such things as the taxonomic position of the animal, its significant morphological features and so on. Viewers use their existing mental models as referents, and learning is about extending an existing mental model by utilising new information (Johnson-Laird, 1983).

The comparatively few data that exist suggest that, when children view animals, they identify certain striking features of the organisms. In particular, they notice anatomical features - such as the dimensions of the animal, its shape and its colour - and comment especially on its front end, on its legs, on other disrupters to its outline and on any unfamiliar organ (Tunnicliffe, 1995). These striking features become the defining ones for the children's constructions of animals and become incorporated in their mental models of different kinds of animals. The features of an animal which are the defining ones for a child can be revealed by obtaining representations by the child of specimens which the child has viewed. These representations may be written descriptions, oral descriptions, drawings or three-dimensional models.

Methodology

Our data were collected in two ways, one approach being used for the museum study and another for the classroom study.

The museum study

The robotics data in the museum were collected between 1993 and 1997 at two separate dinosaur exhibits in the Natural History Museum in London, UK. One of these exhibits was of a single robotic - a small animated dinosaur - placed in a transparent tank at the exit of the main gallery. This exhibit had neither labels nor any accompanying information. The model was programmed to make a sequence of movements in a regular cycle, stretching one of its back legs, moving its tail, opening its eyes and breathing. Its aim was to stimulate inter-visitor discussion about similarities between the dinosaurs and modern reptiles. The other much larger exhibit occupied the width of the gallery at the end away from the entrance. he visitors came from the mezzanine walkway down a slope as they viewed the diorama and ended at ground floor level. The area was darker than the rest of the gallery. It contained a total of four dinosaur robotics: three small meat-eaters (*Deinonychus*) attacking one larger herbivore (*Terontosaurus*). These four models were set in a detailed reconstruction of the presumed habitat and were accompanied by labels and a brief explanatory text.

The majority of the preserved animals which the groups viewed were traditional, taxidermically preserved animal exhibits within a glass exhibition case. These cases were either free standing, enabling the children to move around the animal, or sited against a wall so that the animal could be viewed only from one direction. Some school groups visited the three African dioramas created by Roland Ward which replicate naturalistic African scenes as well as displaying a realistic exhibit of mixed species. A few exhibits, such as the elephants and the model of the blue whale, both in the Hall of Mammals, were not enclosed in glass. Most of the exhibits had few if any accessory items which give clues about the natural habitat. This absence of habitat clues was most apparent in the free standing exhibits. Clues were more frequent in the 'wall' exhibits where there was a backdrop but were most prevalent in the dioramas.

The primary schools with whom the work was conducted agreed to be part of the study. The pupils were aged between 3 and 12 and were not accompanied by museum staff, solely by their teachers and other adults (e.g. parents assisting the teacher supervise the pupils on their trip). Unsolicited conversations heard in the museum were tape-recorded, transcribed and then analysed. A total of 829 'units of conversation' were recorded, 422 of them at the robotics and 407 of them at the conventional preserved specimens.

A unit of conversation was defined as beginning when a group started talking at an exhibit and concluding when they stop talking. If the group stopped, moved on then talked again at the same exhibit but in a different position the conversation was counted as a separate unit. These units provide the raw data of this study. For the purpose of illustration, here is a typical unit of conversation obtained from a group of Reception pupils at the dinosaur diorama:

Girl:	I can't see! I can't see!
Teacher:	This one's dead and what are the others going to do to it?
Girl:	Eat it. Oh no, oh no!
Teacher:	Tracy is crying.
Girl:	Erg!
Teacher:	They are not real!

Each comment within a unit of conversation was coded according to a systemic network which is a type of analysis that changes qualitative into quantifiable data and was developed from the work of Bliss, Monk and Ogborn (1983). There were 74 categories in this network *part* of which is shown in Figure 1. (The full network is available from us but runs to several pages.) Here, a bar, '[', indicates that a comment falls into one of two exclusive categories or groups of categories, whilst a bracket, '{', indicates one of a number of categories into which a comment may fall. Various other descriptive demographic data such as the types of animal observed and the type of adult accompanying the group were also recorded.

The four major categories of the network were:

- Management and social comments which were comments to pupils (whether from an adult of other pupils) about getting a move on, behaving appropriately and so on.
- Exhibit-focused comments which were about labels, settings and so on.
- Exhibit access comments which were about finding and locating the animals.
- Animal-focused comments which were about the animals.

Animal-focused comments were allocated to one of six subordinate groups, namely:

- Interpretative comments which were questions, statements such as 'I know' and 'This is...' and anthropocentric comments or references to the topic from school or home.
- Affective comments which included emotive responses such as 'Ah!' and 'Ugh' as well as comments about such things as animal welfare.
- Environmental comments which referred to a natural habitat or endangered status of a species.
- Body parts comments which are comments about an animal's structure (see Figure 1).
- Comments about the animals' behaviours which included the position of the animal in its enclosure and any 'attention attractor' behaviour which attracted the attention of the visitor, such as mating or fighting.

- Comments about the animals' names.

For each conversation unit the appropriate terminals were identified. If at least one instance of terminal use was identified the code '1' was entered in the appropriate cell of a data sheet. The numbers at the right hand side of Figure 1 refer to the terminals of the body parts part of the network.

Each conversation unit was categorised with the appropriate number from the networks. A typical example is provided below:

Boy: See that, horns, ugh!
Girl: Ugh!
Teacher: Why don't you like it? It's a chevrotain.

(Mammal gallery 9-10 year-olds)

The above exchange, was coded as follows:

Boy: See that, horns, ugh! 71, 21, 28
Girl: Ugh! 28
Teacher: Why don't you like it? It's a chevrotain. 13, 24, 56

Further information about coding, including a complete description of the systemic analysis, is provided in Tunnicliffe (1995).

The classroom study

Fieldwork was carried out in two state schools in the South of England, UK: 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 fieldwork was conducted in a separate room (in the secondary school) or in the corner of a classroom (in the primary school) in 1997.

A total of 36 pupils (nine aged 5, nine aged 8, nine aged 10 and nine aged 14 years) 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'). Six animals were used in the classrooms: (i) a stag beetle (*Lucanus cervus*); (ii) an edible crab (*Cancer pagurus*); (iii) a common house gecko (*Gehyra mutilata*); (iv) a European starling (*Sturnus vulgaris*); (v) a common long-nosed armadillo (*Dasypus novemcinctus*); (vi) a stoat (*Mustela erminea*).

Each pupil was shown a collection of six animals consisting of single whole, preserved specimens of the six animals listed above. The pupil was first asked to put these animals into the order in which s/he would like to talk about them. The researcher then presented the animals individually in this order. For each animal in turn the pupil was asked a series of questions about what the animal was (an X), why they had named the animal thus and what made it an X. 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 made of the name, age, sex and ability range (as defined by the teacher) of the pupil. The answers obtained from the interviews with the animal specimens in the classroom were analysed in a similar way to the spontaneous conversations using the relevant parts of the systemic network. Further details about methodology are provided in Tunnicliffe and Reiss (1999).

Results

The museum study

The contents of the conversations that were generated at the Natural History Museum by primary school groups at the two different types of animal exhibit are shown in Table 1. This table shows that there are both interesting similarities and interesting differences between the conversations.

In terms of similarities, it is clear, for a start, that virtually all the conversations (97% at the preserved animals and 95% at the robotic models) include interpretative comments. Examples of this type of comment are 'Are they real?', a teacher asking 'Which one makes the loudest noise?' and a statement about a robotic dinosaur from a six year-old boy, 'It's got to be real because it moved'. In addition, most conversations (61% at the preserved animals and 73% at the robotic models) include comments on the specimens' anatomy . For example, a ten year-old boy remarked about the meat-eating predator dinosaurs, 'They use their claws', and a seven year-old boy commented about the dying *Terontosaurus*, ' ... that big thing, his leg keeps moving' [though 'moving' is a behaviour comment]. Equally, most conversations (66% at the preserved animals and 72% at the robotic models) included management / social category comments. For example, a teacher telling her group, 'Can you move down?' and a twelve year-old girl urging her companions, 'Come on!'.

However, there were also some very marked differences between conversations at the preserved animals and the robotics. In particular, the preserved animals generated far more naming comments (85% versus 42%) while, as might be expected, the robotics generated many more comments about behaviour (66% versus 37%) and about whether the animals were real/alive (38% versus 15%).

Table 2 shows in more detail the analysis of the conversations that contained animal-focused comments. It is apparent that the reason why robotics generate more comments about behaviour is principally because they generate far more comments about locomotion (59% versus 4%) and food (30% versus 7%). In addition they generate more 'attention attractor' comments, which is not surprising because the models were moving and these movements attracted the attention of the visitors.

Similarly, Table 2 shows that names were much more likely to be used at the preserved animals. Each of the preserved animal exhibits had a different type of animal in contrast to the dinosaur exhibits which were of the same kind of animal - dinosaurs - and where there were only three different dinosaurs, one of which was unnamed. Fewer mistakes were made when identifying the dinosaurs. Again, this is not surprising as there were only two named dinosaurs. Fewer comments were made comparing the dinosaurs to other creatures, and most of these were likening the models seen to types of dinosaur known, particularly *Tyrannosaurus*.

The classroom study

After pupils had arranged the animals in an order, they were asked to name each of the six specimens. In all, 93% of the presented specimens (n = 216; 6 animals to each of 36 pupils) elicited a name (e.g. 'Newt' (9 year-old girl), 'It's a blackbird' (9 year-old girl)) or category (e.g. 'It's a reptile', 'It's got 6 legs which makes it a beetle' (two 11 year-old boys). The remaining 7% of presentations resulted in 'Don't know' or an equivalent.

The reasons given by pupils as to why they had named each animal as they had were categorised as 'Anatomy', 'Behaviour' or 'Habitat'. For example, in the following response to the starling made by a 14 year-old girl - 'Claws to grasp on branches' - 'Claws' was categorised both as 'Behaviour' ['to grasp on branches] and 'Anatomy' ['Claws' being a part of the body]. The following response by a 14 year-old girl to the armadillo was categorised as 'Habitat': 'It lives near roads in Texas - we ran over some when we lived there'. Table 3 shows the number and percentage for each age class of responses. A total of 216 animal 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 the great majority of pupils give anatomical reasons (87%) rather than behavioural reasons (10%) or reasons based on habitat (3%) for naming the specimens. There is no significant evidence that different age groups differ in the reasons they use, though there is a hint that older (14 year-old) pupils are more likely to use habitat as a reason. This could be due either to younger children not knowing the habitats of certain of the animals 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 animal was an X (e.g. why the presented stoat was a cat if the pupil had named it a cat), 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 cat?'). This was to investigate in more depth the attributes used by pupils when identifying animals. As before, responses were classified as 'Anatomy', 'Behaviour' or Habitat'. These are recorded in Table 4. Again, anatomical reasons predominated. A nine year-old girl said about the starling, which she had named a blackbird, 'has a beak and feathers and long thin claws'. A ten year-old boy identified the skink as a lizard 'because it has scales, feet and the bottom is to grip'. A 14 year-old boy said the stag beetle was 'a big beetle - legs, claws and wing cases'. However, reasons based on behaviour and habitat were more important than when simply explaining why an X is an X (Table 3). For example, an 11 year-old boy said that to be a bird an animal needs 'wings and a beak to eat with and catch things'. Further, there is more evidence now that older pupils are less likely to rely solely on anatomical criteria.

Discussion and Implications

The museum study was conducted with groups of pupils on school visits to the Natural History Museum in London where the children's spontaneous conversations at preserved animals or robotic models were recorded. In the classroom study, though, preserved museum animals were taken to a school for individual children's responses to a series of pre-determined questions to be recorded.

When presented in the classroom with an animal specimen and asked to name it and to say what features it possesses that are salient to them in naming it, children have to recall their existing mental model of 'closest fit' and match that to the animal they see in front of them. In this study, striking features such as the carapace of the crab, the wings, beak and claws of the starling, the bony scutes which form the 'armour' of the armadillo, the tail, face and colour of the stoat, the tail, skin and toes of the gecko and the mandibles of the stag beetle were all important. Overall, anatomical features were cited far more often than behavioural or habitat features. Some pupils linked anatomical features to where the animals lived and to certain behaviours it must show.

The specimens in the museum are not presented in an individual manner nor does the child have, as s/he does in the school-based study, the undivided attention of an adult guiding them through a series of questions about the animals. The museum experience is, in that sense, impersonal and optional. Robotics tell a clear, but short, story to which children typically attend closely. On the other hand, the preserved animals tell a more complex but less authoritative tale. Pupils may either attend whole-heartedly to this or may combine it with their own tale(s), using visual (and possibly other, e.g. auditory) cues provided by the specimen combined with their own memories and/or imagination.

It is hardly surprising that, when presented with isolated stuffed animals, pupils mainly use anatomical cues, rather than behavioural ones or ones related to habitat (though even in the case of living animals in zoos, it is anatomical features that are commented on predominantly (Tunnicliffe, 1995)). Nevertheless, the fact that so few pupils in the classroom study used any knowledge about the habitats in which the animals naturally occur possibly reflects the emphasis in much of science teaching on naming and categorising organisms as isolated entities (Tunnicliffe and Reiss, 1999). A different approach would be for teachers to start with environments and their significant features and then discuss with pupils how particular organisms found in such places are adapted to their habitats. Other research has suggested that few pupils have such an integrated understanding of environments (Brody, 1994; Strommen, 1995).

The museum animals present an image which contains clues to their identity, behaviour and habitat. These are conceptual clues which children sometimes use to talk about imaginary scenes in which the animals exhibit behaviours. Such stories are often prompted by the background to the exhibit in a museum. However, in the classroom the children had no 'props' to give then cues other than the animals themselves. Thus in the museum the perceptual clues provided by the exhibit give children a framework for a story of their own making. On the other hand, in the classroom these exhibit cues are absent. In both situations, though, pupils relate their observations to their own previous experiences - such as seeing the animal in a wood, on the television or in a zoo.

The moving robotic animals provide a strong story line which children tell, but they may also embellish it and provide their own interpretations: for example, at one of the robotic exhibits a pupil interpreted the smaller carnivores eating the larger herbivore as babies eating their Mummy.

The museum conversations analysed here suggest that such far less scientific learning takes place than could be the case. Rather than being taught much in front of the specimens, children simply use their everyday knowledge and understanding to interpret what they see and to allocate everyday names using anatomical clues as their guide. The baseline of content provided by this study can be used to develop the science education offered within museums and schools by both museums and schools so that a progression in content of observations is developed. The progression must start with the everyday observations which the children bring to encounters with these representations of animals and build to include more formal accepted biological understanding.

All three kinds of three-dimensional representation discussed here - preserved animals in museums, robotic models in museums, preserved animals in schools - provide the learner with opportunities to see anatomical features more fully than is the case with two-dimensional representations whether moving (as in films) or stationary (as in books). Such opportunities give a teacher the chance to discuss these anatomical features and introduce those which are used by zoologists in categorisation. Similarly, three-dimensional representations, especially robotics and carefully positioned preserved specimens, provide clues about characteristic behaviours which the children may pick up or the teacher can extend.

But to achieve greater depth of understanding in their pupils than is often the case teachers need themselves both to have a secure biological knowledge - so that they know, for example, what are the biologically significant features that characterise dinosaurs and mammals and the range of habitats in which such organisms are found - and to have the ability to teach their pupils to observe carefully and to extend their thinking. Trips to museums and zoos are not simply 'days out'. It is possible for them both to be enjoyable and to provide unique learning opportunities. In the same way, animals (whether preserved or living) brought into school can provide an enjoyable and different learning experience which enables pupils to use their own previous knowledge and experiences about animals to aid the development of their further understanding.

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Table 1

Comparison between the Number of Units of Conversations[1] of School Groups at Preserved animals and Robotic Models (Major categories)

Category	Preserved animals n= 407	Preserved animals %	Robotic models n = 422	Robotic models %	χ^2
Management / Social	270	66	304	72	3.2
Exhibit access	219	54	239	57	0.7
Other exhibit comments	220	54	173	41	14.2**
All anatomical comments	243	61	309	73	17.0**
All behavioural comments	152	37	363	87	208.6**
All naming comments	344	85	176	42	162.4**
Affective attitudes	158	39	229	54	19.9**
Emotive attitudes	145	35	199	49	11.4**
Interpretative	395	97	400	95	2.7
Real / alive[2]	65	15	170	38	60.3**
Knowledge source[3]	296	72	329	78	3.0
Environment	45	11	19	5	12.5**

** $p < 0.005$

[1]In all tables, the data refer to units of conversations that contain at least one comment in a given category. The categories are not mutually exclusive so percentages in sub-categories may add up to more than 100%.

[2]Comments in this category were ones which questioned or discussed whether the animal was real and alive.

[3]Comments in this category were where group members referred to the source of their knowledge. Such comments were predominantly personal using statements like 'I think that...' or 'I know that....' or asking questions of others. References to books, displays and other sources of information were rare.

Table 2

Comparison between the Number of Units of Conversations of School Groups at Preserved Animals and Robotic Models (Animal-focused Comments)

Category	Preserved animals n= 407	Preserved animals %	Robotic models n = 422	Robotic models %	χ^2
All anatomical comments	243	61	309	73	17.0**
front end	67	17	113	27	13.0**
dimensions	198	49	173	41	4.9
unfamiliar	67	17	59	14	1.0
disrupters	39	10	162	38	93.7**
All behavioural comments	152	37	363	87	208.6**
position	69	17	80	19	0.6
locomotory	40	4	249	59	220.6**
food-related	28	7	127	30	73.5**
attention attractors	63	16	182	43	76.1**
All naming comments	344	85	176	42	162.4**
label	297	74	147	35	121.2**
category	232	57	85	20	119.2**
compare	166	41	41	10	106.8**
mistake	23	6	6	1	na[1]

** $p < 0.005$

[1]Not applicable. Cell size too small.

Table 3

Reasons given by pupils for naming each specimen in the classroom study as they did.

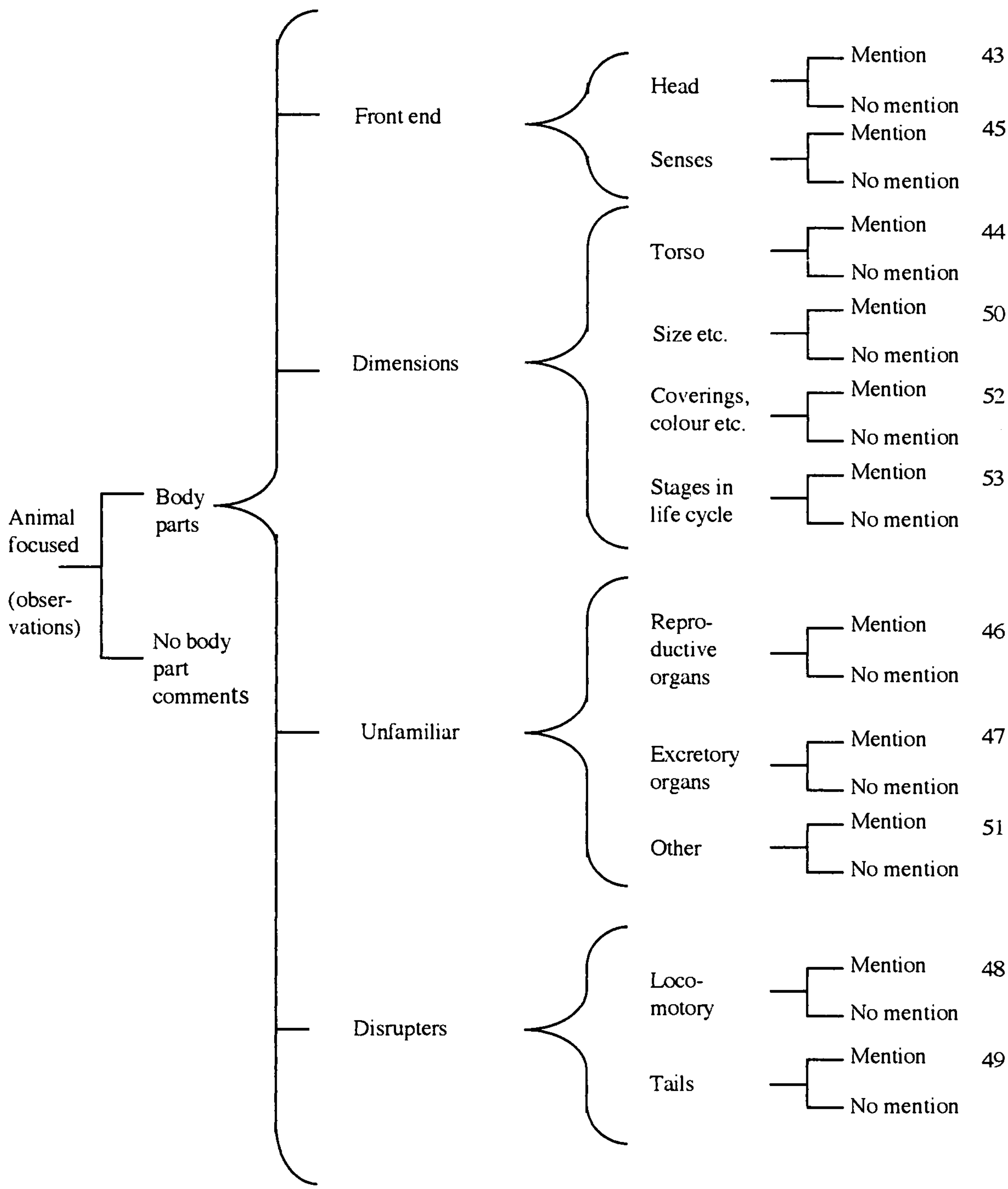
Reasons used	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 231
Anatomy	46 (85%)	50 (91%)	54 (96%)	52 (79%)	202 (87%)
Behaviour	7 (13%)	5 (9%)	1 (2%)	9 (14%)	22 (10%)
Habitat	1 (2%)	0 (0%)	1 (2%)	5 (8%)	7 (3%)

Table 4

Reasons given by pupils as to why each specimen in the classroom study is what they said it is.

Reasons used	5 years n (%)	8 years n (%)	10 years n (%)	14 years n (%)	Total n = 264
Anatomy	43 (80%)	52 (88%)	53 (71%)	54 (71%)	202 (77%)
Behaviour	9 (17%)	6 (10%)	17 (23%)	17 (22%)	49 (19%)
Habitat	2 (4%)	1 (2%)	5 (7%)	5 (7%)	13 (5%)

Figure 1. *Body parts segment of the network.*



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