



Observing mealworms in the primary classroom

■ Sue Dale Tunncliffe

Why look at animals in class?

There is a partnership in science education – between teachers and their pupils. The teacher is alert to opportunities for developing pupils' knowledge and understanding of what is accepted in society as 'science'. The pupils reveal their personal constructs by commenting on what they observe and how they explain the phenomena they see. There is also a 'duty' for teachers to not only help children learn what is deemed essential by the state, through a National Curriculum, but also to provide these learners with a forum in which to explore their feelings and learn some biology (Tunncliffe & Uekert, 2007). The science to be taught is set out in the English National Curriculum (DFE, 2013) and the place for teaching is usually the classroom.

Children come to their biology education experience with existing mental models about phenomena, which they form from their own encounters in their formal studies in school, on a field trip or playing outside. These 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). The mental model is the person's personal knowledge of the phenomenon – in the case of this article, a specific animal species – and will have similarities to and differences from the scientifically accepted knowledge, which, in this instance, is about such factors as the taxonomic position of the animal, its significant morphological features, and so on.

Basic human anatomy and physiology are topics that are always studied in primary schools, but other living organisms should be an integral part of

the primary classroom, not only for the science that can be learnt from them, but also for affective reasons. Existing work suggests that, whilst observations that are carried out for learning the facts of science are important, the personal aspects of the interpretation of observations are a key part of the experience for the pupils (Tunncliffe & Reiss, 1997). The benefits of keeping animals in classrooms have long been recognised. Examining live organisms for themselves motivates pupils and renders teaching more effective, as well as engendering concern for the organisms, (Cassidy & Tranter, 1996), a concern that can be developed for other species as well as environmental issues.

Previously reported work carried out in zoos and a natural history museum reveals that pupils of primary age look at the specimens on display and notice salient features of anatomy, such as size, colour, legs and tails, and those behaviours that occur in front of them (Tunncliffe, 1996a, 1996b; Patrick & Tunncliffe, 2011). These studies showed that early childhood primary-aged children notice animals in their everyday lives. Children of this age also provide animals with an identity, which reflects an everyday system for naming. Scientific names are hardly ever used unless, as in the case of dinosaurs, there is no everyday equivalent. The official common names (such as flour beetle in this instance, rather than the everyday name, mealworm) are hardly ever heard (Tunncliffe, 1995).

Relatively little is known both about the responses of pupils of under eleven years of age when observing live invertebrate animals and whether science inquiry skills (Turner, 2012) could be met through such studies.



Why mealworms?

Certain invertebrate animals, such as mealworms, are a judicious choice to use with primary children. These animals are easy to look after and have less demanding requirements than many other specimens, invertebrates or vertebrates. Animals used in primary classrooms need to be easily obtainable, easy to care for, require cheap, safe and appropriate housing, have manageable temperature and food requirements, proffer minimal safety risks and health hazards and yet be active so that they engage the attention of pupils. Moreover, species used with primary children should have the potential to be the focus of investigations, which the pupils can design and carry out, as well as being part of discovery learning where the pupils carry out investigations prescribed by someone else. Animals most often studied in primary classrooms, for instance woodlice and snails, more often than not are returned to their original habitat after completion of the investigation, so removing the possibility of observations and investigations over a period of time.

In addition, mealworms are frequently referred to as merely 'worms'. Indeed, a 2 year-old in a stay-and-play science session in a North London nursery last summer immediately named the mealworms on an observation table as 'worms'. This is an excellent example of the need for human beings to identify that which they see to the nearest category that they recognise and in which they see similarities.

Mealworms and the science curriculum

I wanted to explore the educational potential in terms of spontaneous interest from pupils in an organism that can live permanently within a classroom and require minimal maintenance, but which can also provide excellent opportunities for pupils to learn relevant science curriculum concepts. I also wanted to identify the main topics of comments made by the children when looking at these organisms and whether this content changed with older children. Hence two age groups were chosen.

The English National Curriculum is the minimum entitlement for a child's education in England. Work with mealworms provides opportunities to

contribute to the aims of the curriculum for 'all pupils', which are:

- to develop scientific knowledge, in this case biological, to develop '*an understanding of the nature, processes and methods of science, such are achieved through different types of science enquiries that help them to answer scientific questions about the world around them*';
- to become equipped to be able to understand uses and implications of science;
- to be drawn together and the foundations laid in this work for further development up the school (DfE, 2013).

English state schools are very focused on assessment, and listening in a structured way to what pupils say can reveal what they notice and how they interpret these individual or group observations, as well as what questions these raise in their minds and what further investigations or knowledge they need and can be encouraged to find out.

I considered that work with mealworms could provide opportunities for the learning of science, facts, process skills and general issues, as well as for observations and interpretations from the children, an important inquiry skill (Turner, 2012). Listening to children's comments, as well as indicating what questions the observations raise in their minds, can reveal what further investigations or knowledge they want and need for meeting curricular requirements, as well as suggesting accessible targets that they can be encouraged to explore and find out for themselves.

Discussion about mealworm larvae and adult mealworms can help children clarify the classification of those animals that undergo a complete metamorphosis and can establish that both larvae and beetle are the same kind of animal, an insect and, at the same time, also called an animal, hence they are a 'mealworm' (*Tenbrio*) – beetle-insect-animal. This is a difficult concept for some children to master (Allen, 2010). Using mealworms, which are familiar to some children, with the expectation that, through looking at them, the children may give them an everyday name, was of interest to me.

Some animals that undergo complete metamorphosis look distinctly different in their young stage, their change stage (when their internal anatomy and external features are rearranged) and in the adult form. This phenomenon causes problems for learners in identifying these physically different-looking beings as the same type of animal but at different stages in its life. For example, a caterpillar does not resemble its adult form, the butterfly, nor does it look like the chrysalis (when it undergoes its change from young to adult). Children have to learn to recognise all three forms of the same animal as different. Each stage of its life history looks very different to the next stage; in the case of mealworms, the larva is long and segmented with three pairs of legs behind its head; the pupal or change stage is of a different shape and colour; whilst the adult, the imago or beetle, is brown and in a different form, with wings and wing case. Such an instance of an animal that differs in appearance at different stages of its life cycle, but which is the same animal, was referred to by Bruner, Goodnow and Austin (1956: 2) as 'identity class', whilst recognising that a different kind of similar-looking larval form, for example a caterpillar and the mealworm larva, are members of an 'equivalence class'.

The research animals

The animals used in this study were specimens of *Tenbrio molitor*, readily obtainable in their larval form from pet shops, where they are sold as food for other animals, usually reptiles. These animals are very easy to keep in classrooms and, as far as is known, they cause no allergies in children. They can be left with sufficient food and a moisture source (a piece of cut potato for example) over weekends and holidays and so the whole life cycle of an animal with complete metamorphosis can be observed. These animals are far more satisfactory for young children to study than dealing with caterpillars purchased by the school, with these frequently dying following the emergence of the imago.

A mealworm has a different form in each of the three stages of its life cycle. At the young or larval stage, it is a long segmented animal with 3 pairs of legs at the front end and a support leg on the last segment of the body. The larva, when it first

hatches, is 1cm long. As it grows, it sheds all its body covering, its skin, which is a *chitin exoskeleton*. At the final larval stage, the animal is about 3cms in length and moves relatively quickly. The change, or pupal, stage (when it is undergoing complete metamorphosis) reveals an animal that is white and curved and largely quiescent, and the adult, or imago, takes the form of a light red-brown beetle, about 1cm in length, when it first emerges, whose colour darkens as it ages. Full details about mealworms can be found in CLEAPSS (2005).

The research questions

My research questions were:

- What do primary school children say when they are asked to observe mealworms?
- Do these comments vary as children grow older?

To answer these questions, I carried out a project in a voluntary-aided Church of England school in a town in south east England with a relatively low unemployment rate. The Headteacher obtained all necessary permissions and the anonymity of the children participating was observed.

I asked pupils from Years 2 (age 7) and 5 (age 10), in small mixed gender and ability groups, to observe and record a small living invertebrate, *Tenbrio molitor*, with distinctly different physical stages in its life history. Thus, the purpose of the study reported in this article was to find out what observations pupils of primary age made when asked to observe and record a small living invertebrate in the classroom, with the aim of building up information about pupils' responses to differing organisms in order to help teachers select the species most appropriate for helping children to learn particular concepts such as classification, structure of taxonomic groups, behaviour and responses, and life cycles.

Methodology

Organising mealworm observations

Each group of pupils was provided with a see-through plastic vegetable container measuring 15 x 9 x 8cm with bran at the bottom, which contained several specimens of the larvae, pupae and imago, so that they could easily observe the three stages

of the life cycle with the naked eye. Hand lenses (x10), plastic petri dishes and see-through straws were provided as tools to enhance observations.

Firstly, the pupils were asked to observe and then, secondly, say what they noticed about the animals. I recorded their conversations and analysed the content in the same way that I had done in previous studies (Tunncliffe, 1996). The majority of comments were about the animals. Other comments were about the activity, and the items that the children were using. The animal-focused category was sub-categorised into six subordinate groups to which comments were allocated:

- Interpretative comments, which included knowledge source comments such as questions and references to a source of the information proffered;
- Affective comments, which included emotive responses such as 'Ah!' or 'Ugh';
- Environmental comments, which referred to the natural habitat;
- Comments about the animals' structure;
- Comments about the animals' behaviour; and
- Comments about the animals' names.

The comments about the anatomy and behaviour of the mealworms were grouped into four main categories, of which three were anatomical:

- those concerned with the front end of the animal;
- those associated with the dimensions of the animals;
- those features that were unfamiliar to the observers, which included structures such as antennae, and disrupters (the legs of an animal that disrupt the outline of the animal's shape).

Comments on behaviours included the position of the animal movement, feeding and anything else, such as apparent mating, which caught the attention of the pupils.

The numbers in each category for each group were added up. This was based on methodology already having been developed and tried (Tunncliffe, 1996a, b).

Results

All the data from the recording of spontaneous dialogue were transcribed, and were counted and, thus, an overview of the frequency of mention of certain categories that emerged from the 'read/re-read' technique, but which were the same as those previously found in the researcher's work, emerged. Table 1 shows the categories of conversation in which the main topics were mentioned by the children:

Table 1. Number of conversations of all pupils in which the main topics are mentioned at least once in a conversational unit (n = 308).

Topic	mealworms no. (n=308)	%
Management /social	240	78
Exhibit access	89	29
Other items	169	55
Body parts	223	72
Behaviour	213	69
Names	188	61
Affective attitudes	155	50
Emotive attitudes	148	48
Interpretive	302	98
Knowledge source	280	91
Real/dead	57	19
Environment	15	5

Firstly, the pupils talked about the animals. Secondly, half the conversations also referred to something else associated with the animals, such as a tool to enhance observations, as the following conversation between Year 2 pupils shows:

Boy 1: My tube's [the see-through straw] gone. Where's my tube? Where did you get that tube from?

Boy 2: Luke, Luke!

Boy 1: My tube's gone, oh, there it is!

A more detailed analysis of the comments (see Table 2) shows that the majority of the comments were about the dimensions of the animals, their shape, size and colour, and stages or roles in their life histories. Conversational unit 4 considers life histories and the body, as well as numbers of legs:

Conversational unit 4 (Year 2):

Boy: *It's a mummy one!*

Teacher: *It's a mummy one, is it?
How can you tell that?*

Boy: *'Cos Daddy ones have more legs at the back than at the front and mummies have babies.*

Table 2. The number of times that body parts or behaviours were mentioned at least once in a conversation.

Body parts & behaviour mentioned	no. n=308	%
Topic		
Body parts	273	72
front end	38	12
dimensions	169	55
unfamiliar	66	21
disrupters	84	27
Behaviour	213	69
position	99	32
movement	151	49
food related	39	13
attractors	83	27
Names	188	61
identity	187	61
Affective attitudes	155	50
Emotive attitudes	148	48
Interpretive	302	98
Knowledge source	280	91
Real/dead	57	19
Environment	15	5

However, few pupils remarked about the head end and legs.

Conversational unit 5 (Year 2):

Boy 1: *I'm going to draw it!*

Boy 2: *How many legs has it got?*

Boy 1: *Four.*

Unfamiliar parts, such as antennae or wings, were mentioned in about a quarter of instances.

Conversational unit 6 (Year 5):

Girl: *Ugh!*

Girl: *That one's moving now.*

Boy: *Oh, I know! They have a thing on their heads and little things that they eat with.*

Boy: *Like spiders, like tarantulas, they go [mimes movement of antennae].*

Conversational unit 7 (Year 5):

Girl: *This one looks as if it has wings [pupa].*

Teacher: *Yes, well, if it is going to change into a beetle, it will need wings.*

Girl: *Yes, they have wings on their back.*

Similarly, behaviours that children deemed to be worthy of comment included movement in half of the exchanges heard. The position of the organisms was relatively unimportant because the animals were easily located. Behaviours that attracted comments, particularly fighting or mating, were mentioned in over a quarter of exchanges. Behaviours provide many examples of pupils interpreting what they see from their own experiences using metaphors. A Year 2 boy commented that *'They are both cuddling'* as he watched two larvae entwined as they moved across each other. Comments about feeding were relatively infrequent and comments were associated with movement.

Conversational unit 8 (Year 5):

Girl: *That one's digging.*

Teacher: *Why do you think they are doing that?*

Girl 1: *For food, why do they need food? They are living in it.*

Girl 2: *Oh, yeah.*

Boy: *I wish I could live in my food!*

Girl 1: *Do they, you know, mate?*

Girl 2: *I just found a maggot underneath.*

Names were used in just under two thirds of conversations. Names give an identity to the organisms and reflect the previous experience of the pupils. Hence, one boy wondered if the larvae were baby snakes. In Conversation unit 9, Year 5 girls (10 year-olds) talked about shells, a molluscan feature, but frequently used to refer to any hard covering on an animal by both children and adults.

Conversational unit 9 (Year 5):

Girl 1: *Maggots, huh, has...*

Boy: *Maggots! What kind of maggots?*

Girl 2: *And there's one here that's got cracked shell but it's still alive [beetle with half an elytra].*

Girl 3: *Oh yeah, oh, you can blow though them [using the straws].*

- Girl 2: *Yes, used to blow through them.*
- Girl 1: *Beetles only have black backs.*
- Girl 2: *Yes.*
- Girl 1: *They are insects because insects have 6 legs and that's what they [are] called.*
- Girl 2: *There are the maggots like fishing ones. Actually, they are not maggots, it's what they call centipedes.*
- Boy: *No, they don't use big ones, like those.*
- Girl 2: *Yes they do.*
- Girl 1: *They move with muscles.*
- Girl 3: *Yeah, they move with muscles. Their legs... one goes up to the front and one goes up in the middle and then the back ones come. They have come out of their shell, that's what it looks like!*

A number of pupils identified the larvae as maggots (unit 12), but correctly categorised the imagos as beetles (unit 9), yet were able to identify a stage in a life history in which form changed between stages (unit 13). Pupils were apparently using an everyday way of categorising the animals (Tunncliffe, 1995). However, the pupils had two issues to contend with in naming mealworms; firstly the type of animals and secondly the stage, recognising that the different physical stages they observed were in fact in members of the same species but at different stages in the life cycle, identifying class as well as the equivalence class (Bruner, Goodnow & Austin 1956: 2). The girls in Conversational unit 9 recognised that the organism identified as a beetle is also a member of the insect group, hence permitting the organism to have two names at the same time, being both beetle and insect, a phenomenon that pupils under seven find difficult to grasp (Markham, 1989). The larvae, however, were identified as maggots – something different in biological terms but an everyday category used by non-biologists to represent small-segmented organisms.

The movement of the mealworms attracted comment and they were described with all their salient features:

Conversational unit 10 (Year 2):

- Boy: *Ugh, look at that white one, look at that moving big thing there and they turn into that white thing and then they turn into a beetle.*

Lack of movement suggests that the animal is dead. The following conversational unit also shows how pupils matched the unfamiliar and unknown (the mealworm larvae) with something similar that they had encountered (the leather jacket larva) and provided a name and identity for the animals:

Conversational unit 11 (Year 5):

- Boy: *Strange, look at that moving thing there, look at that maggot.*
- Girl: *Look at that one, that's all died.*
- Boy: *I've seen those before, my dad found one in the ground [a leather jacket, perhaps?].*

Anatomical features are observable, but there is a tendency to notice the salient features, such as size and colour, unless encouraged to look at other features important to science learning, such as number of legs.

Conversational unit 12 (Year 2):

- Teacher: *Do you know what they are and how many legs they have? What else can you see?*
- Boy 1: *They are maggots.*
- Boy 2: *Maggots, what's that?*
- Girl: *The big fat white ones and black ones. Look, Ross, one of those they have black, look, they go into black and turn into a beetle.*
- Boy: *Ugh, we've got a black one.*
- Teacher: *They turn into beetles, that's right.*

The stage in a life cycle is identified based on expectations from other learning experiences and on size, a criterion often used by young children (Loft, 1971)

Conversational unit 13 (Year 2):

- Boy: *I've seen a mummy one.*
- Teacher: *You've seen a mummy one? How do you know it's a mummy one? You can't just say 'I've seen a Mummy one', how do you know?' How do you know it's a mummy one, you tell me?*
- Boy: *Hm. Mummy ones are these ones [pupae], daddy ones can be longer.*
- Teacher: *So the mummy ones are the little ones and the daddy ones are bigger?*
- Boy: *Yes.*

Teacher: *Do you know, I don't think anyone knows. The mealworm larvae don't have babies, they have to grow up first.*

Boy: *Maggots.*

In some cases, previous learning is applied. The girl in the following exchange remembered learning about caterpillars and was able to apply the knowledge, largely unnoticed by the rest of her group:

Conversational unit 13 (Year 5):

Girl 1: *Ugh!*

Boy: *Dead, dead,*

Girl 1: *Some are dead.*

Girl 2: *That's turned into a chrysalis.*

Boy 1: *That one's squashed.*

Both: *Ugh!*

Boy: *Have you seen anything like this before?*

Girl 2: *The chrysalis, it's got buried there.*

Boy: *They can flick over there.*

Girl 1: *It's dead.*

Boy: *That maggot, that will eat that.*

The above conversation shows the frequently-used criterion for being alive: movement.

Some pupils began to categorise the animals spontaneously; for instance, in Conversation unit 14, which provided an opportunity to develop categorisation or grouping in biological taxonomy terms, rather than everyday taxonomies, which are persistently referred to elsewhere in the conversational exchanges reported in this article: minibeasts, maggots and worms.

Conversational unit 14 (Year 5):

Boy: *They're kinds of maggots, but they are not, they are worms.*

Teacher: *No, they are not worms, are they, because do worms have legs?*

Boy: *No, they are part of things.*

Teacher: *Come on, what sort of animals are they then? These are all called mealworms, but what group of animals do they belong to?*

Girl: *Worms?*

Teacher: *No.*

Girl: *Beetles.*

Teacher: *Yes, and what group do beetles belong to?*

Girl: *Larvae.*

Teacher: *No, being a larva is part of being a beetle. If you had to group the animals?*

Girl: *Minibeasts.*

The data show that younger pupils are more interested in the tools they can use ($p < .005$) than older ones, although pupils at both ages were interested in and commented on these.

Conversational unit from older pupils focused on tools including a scientific observation:

Boy: *Can I use a magnifying glass?*

Girl: *It is an insect because they have got 6 legs.*

Boy: *Can I use a magnifying glass?*

Age-related differences in the emphasis of conversations

Although both age groups named the animals in similar numbers, the older pupils referred to behaviour ($p < 0.01$) and structure ($p < 0.025$) more than the younger ones. Conversely, younger pupils made more interpretative comments ($p < 0.025$) and significantly fewer ($p < 0.01$) affective attitudes, which included emotive ones ($p < 0.025$). Young pupils did not comment as much on a number of categories compared to the older children (see Tables 3 and 4).

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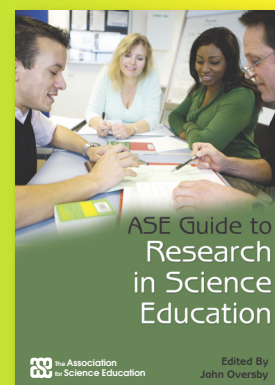


Table 3. Content of conversation units about mealworms shown according to age groups.

Category	age group 2 n=167		age group 1 n=141		chi ² 1df	Probability	Phi ²
	No.	%	No.	%			
Management /social	131	78	109	77	0.06		
Access	50	30	39	28	0.19		
Other items	98	57	119	84	24.29	p<0.005	0.02
Body parts	130	78	93	66	5.41	p<0.025	0.02
Behaviour	126	76	87	62	6.77	p<0.01	0.02
Names	114	68	73	67	8.72	p<0.005	0.03
Affective attitudes	96	57	59	42	7.48	p<0.01	0.02
Emotive attitudes	91	55	57	40	6.06	p<0.025	0.02
Interpretive	161	96	141	100	5.12	p<0.025	0.02
Knowledge source	155	93	125	87	1.60		
Real/dead	37	22	20	14	3.22		
Environment	13	8	2	1	N/A		0.02

Younger pupils were intrigued by the magnifying glasses and other pieces of equipment made available significantly more than the older pupils, yet they commented significantly less about body parts and behaviour (although such comments still occur in two thirds of conversational units). The younger pupils also made affective comments significantly fewer times. They made fewer comments about the environment although, overall, very few such comments were generated.

Discussion

Developing science skills and knowledge and understanding

Naming something is usually the first narrative action carried out by children and, indeed adults, once the animal has been located. By providing an identity, naming is an important part of the observational process and children then allocate the animals to a category, which functions as a name and also an overarching, or superordinate, category group name.

Table 4. Comments about body parts, behaviour and names according to age groups.

Category	age group 2 n=167		age group 1 n=141		chi ² 1df	Probability	Phi ²
	No.	%	No.	%			
Body parts	130	78	93	66	5.41	p<0.025	0.02
front end	27	16	11	8	4.95	p<0.05	0.02
dimensions	91	55	78	55	0.02		
unfamiliar	45	27	21	15	6.60	p<0.025	0.02
disrupters	55	33	29	21	5.90	p<0.025	0.02
Behaviour	126	76	73	67	8.72	p<0.005	0.03
position	65	39	34	24	7.69	p<0.01	0.03
movement	90	54	61	43	3.46		
food-related	28	17	11	8	5.57	p<0.025	0.02
attractors	49	29	34	24	1.06		
Names	114	68	73	52	8.72	p<0.005	0.03
identity	112	67	75	54	5.57	p<0.025	0.02
category	103	62	73	52	3.06		
compare	41	25	22	16	3.76		
mistake	35	21	16	11	5.11	p<0.025	0.02

This evident preoccupation, or instinctive response, of the pupils with finding or allocating a name or label for the animals is unsurprising, because categorising and then naming that which is around us is a basic human need. In the naming process, pupils are establishing the discernible features through their own observations. They are also beginning to provide not everyday names but science categories. The learner has to be able to recognise the constituent parts if they are to identify specific attributes. In Conversational unit 7, for example, a boy noticed the jaws of the mealworm in action and another boy likened this to the *chelicerae* of a spider, mentioning a tarantula, presumably based on a first-hand or secondary experience. However, before a concept can be categorised, that concept has to be acquired. These children, in some instances, considered the animals to be worms or maggots, whilst in Conversational unit 8, one girl displayed knowledge of a number of arthropod groups.

Pupils were seeking to provide an identity and categorise the animals and some pupils showed evidence of having learnt criterial attributes. Similarly, when a Year 2 boy remarked, '*They are kind of maggots, but they are not, they are worms*', he was beginning to recognise variation in patterns observed.

Work in the primary classroom provides opportunities for learning the constituent parts of the organisms as well as their main behaviours. Pupils observed different stages of the animal within its life cycle and learned to recognise *identity class members* – the larvae, pupae and beetle are all members of the same species. They also learned a number of *equivalence* categories for different types of invertebrate species; centipedes and maggots were mentioned as separate species and not identity class members, which the specimens observed were (see Bruner *et al*, 1956). The primary science name for an artificial category of invertebrates, minibeasts, which came into use in many primary schools in the 1970s, was seldom used by the pupils.

The first-hand observations of mealworms in all stages of their life cycle provide ample and relevant opportunities for pupils to observe the life processes in action, in particular movements and reproduction. The easily observable stages in the



life cycle provide relevant opportunities for introducing or consolidating the concept of complete metamorphosis, linking it with the traditionally-taught tadpole-frog and caterpillar-chrysalis-butterfly cycles, which are often the only examples studied by pupils during their primary education. Some pupils spontaneously applied their knowledge of life histories and different stages to the way they interpreted their observations. Such encounters with the different stages in a life history are important concrete experiences, which assist the learner in moving towards a complete understanding. The mealworm encounter provides a necessary link in learning the universality of life cycles.

Pupils observing mealworms witnessed variation between individual animals, noticing that some are bigger than others, colours differ and appearance varies between life cycle stages. Using mealworms in classrooms is a more satisfactory means of illustrating the concept of complete metamorphosis. Unless there is a pond in the school grounds, the collection of frogspawn from the wild is now illegal. Buying caterpillars, such as those of the Moon Moth, is expensive and very often they or the imago die. Mealworms live happily in their container and reproduce, so can always be viewed. Pupils could, if this study is replicated, be given a key to identify the animal, or they could use the organisms here as part of constructing a key of other invertebrates readily available in primary classrooms and their environs, such as earthworms, woodlice, slugs, snails and spiders.

Once the organisms had been identified and categorised, pupils made observations that could be developed into systematic investigations. The pupils used first-hand experiences as well as secondary ones obtained from teachers and peers. Subsequently, the pupils used drawings provided by the teachers and books to find out more for themselves about the animals. Observations were made based on what was seen. These observations could then be used in drawing and writing about the animals. Pupils used scientific units of measurements. Such opportunities for measuring and using units could be developed further.

Older pupils showed a greater interest in the front end of the animal – the face and eyes – and the unfamiliar and disrupters – legs, antennae and wings. Surprisingly, because younger pupils usually comment more about such aspects (Tverksy, 1984), comments about dimension, size and colour, for instance, were similar in both age groups. The behaviours about which older pupils commented significantly more included the position of the animals and food-related behaviours. Older pupils named the organisms significantly more by providing an identity. However, they also made markedly more mistakes in their naming, often calling the larvae 'maggots'.

Linked with providing an identity for the animals and observing their anatomy and behaviour are opportunities for developing and using appropriate vocabulary for the topic, science process, equipment and measurements. Furthermore, studying mealworms provides an opportunity for Health and Safety issues to be addressed, for instance, washing hands after handling the animals and also showing care and consideration for other living things.

Ideas for investigations emerged from the pupils as a result of their observations. A greater emphasis by the teacher on this, as well as encouraging further opportunities for raising questions would increase the experience of pupils in this area of the curriculum. The pupils were using deductive reasoning based on their own understanding, as shown in the conversation about the rationale behind one life cycle stage representing the mother and another the father.



First-hand observations assist pupils in learning the 'eat and be eaten' cycle of life, or energy flowing in the environment. Pupils can trace the food chain of the mealworms back to plants (in the bran or, more obviously when lettuce leaves or potato pieces are added to the containers) and this can link in with investigative science as well as environment studies.

Mealworms live in a convenient habitat for study in the classroom. Their adaptation to this dry, enclosed and dark habitat can be identified, discussed and contrasted with the environment of other readily available animals, such as the wood louse, pigeon and snail. Meaningful investigations about conditions in the habitat can be designed and effected. Moisture, for instance, may be added to the habitat in the form of pieces of potato and the larvae will develop more quickly. Shining a torch through the base of a clear container can illustrate the negative phototropic behaviour of the animals.

While pupils explored the animals provided with the teacher responding to their observations, on occasion they were given 'secondary' information to develop the observations being made. Thus, the work was of an exploratory nature, within the curriculum focus, and so developed according to the relevant parts of the English National Curriculum. However, the work led to elicitation of the pupils' ideas and formed a meaningful and relevant opportunity for the teachers to encourage them to test ideas against evidence. The task set, to draw the animal and write down a few observations, is very much part of the exploratory phase of learning.

There was a distinct difference in emphasis in the observations made by the younger compared to the older pupils, a different result from studies of observations made at animal exhibits, zoos or museums by children of similar ages (Tunnicliffe, 1995). There may be a number of reasons for this. Pupils were in familiar physical territory and had not had the many and varied affective experiences that form part of the 'field trip' or school outing.

All the pupils could see the animals easily and were able to physically interact with the specimens. Moreover, the task that the pupils were given with the mealworms was simple but clear; often a task set during visits to animal exhibits can be unclear or nebulous.

Any interactions with tools or equipment, after a few practices with hand lenses, were focused on the animals and not on adjacent phenomena, as can be the case with many museum interactive experiences. Such an observation reinforces the need for a spiral curriculum, introducing the topic at different stages in a child's learning journey so that, each time the concept is met as the child matures, they construct further understanding.

Implications

Consideration of the data, quantitative (numbers) and qualitative (words) in the conversations, shows three main things:

- Insight into what the pupils do observe when looking at a living animal. Observations include how pupils name the organisms, what anatomical and behavioural features they notice, and that such observations change in the emphasis of the content as pupils get older;
- Pupils respond to the living animals at all stages of the mealworm life history; and
- The use of mealworms in class provides opportunities to give pupils first-hand experiences, which in turn enable them to fulfil the requirements of the curriculum: science, maths, design and technology, information and communication technology and language.

The use of appropriate live animals in primary classrooms should be encouraged. The observations and investigations focused upon them not only enable teachers to meet the

requirements of the curriculum, but also introduce pupils to the first-hand observations of living things.

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