

Learning in Physical Science opportunities at Natural History Dioramas

Dr Sue Dale Tunnicliffe*, Rebecca Gazey** & Dr Erini Gkouskou***

*Reader in Science Education, UCL IOE

**Learning Officer Powell Cotton Museum

***Lecturer in Early Years Science, UEL

Abstract

Observing natural history dioramas provides learners with opportunities to identify various aspects of biological science captured in the moment of time portrayed in a given diorama as behaviour, taxonomy, adaptation to the habitat including anatomical specialisations and coloration. However such observations also afford opportunities to observe other science phenomena such as earth science in the geology of the habitat or the weather portrayed. This chapter focuses on aspects of physical science in action shown in the animals featured. Very basic ideas such as shape, size, colours and patterns as well as basic numeracy for earliest learners. Older primary children can explore flight and floating and sinking if such are featured in the diorama. Basic forces, balance and centre of mass are shown in most dioramas especially those with terrestrial vertebrates as well as sound and light. Such learning strategies involve knowing the foundation knowledge that the children possess. This chapter focuses on the aspects of physical science which may be identified in natural history dioramas and the responses of some primary children to identifying such for themselves in a natural history museum in the south of England which focuses on African and Indian dioramas. Demographics of the schools where applicable were noted and relevant permissions obtained. Transcripts of the dialogues in workshops and at the dioramas were collected and analysed through a read re-read iterative process through which categories of comments emerged. Simple counts were made of responses. These workshops led to children being able to identify the basic physics in action.

Key Words

Primary science numeracy forces animals

Introduction

Dioramas are a genre of museum exhibit firmly in the museum world with tremendous, often as yet underused, educational potential (Tunncliffe, 1996A). A growing awareness that learning does not solely occur inside the school building, in the case of science particularly in the core of developing and understanding of the nature and content of science which is, in formal education, traditionally taught in classrooms and in many instances laboratories. But learning out of school in a variety of venues is a valuable aspect of learning both of and about science (Dillon, 2015). Science can be learnt in museums. Dillon (2015) points out that science can be effectively learnt outside the classroom on visits to a variety of locations. The socio-cultural context in which a learner is situated is recognised as an important factor in the acquisition of knowledge, indeed termed cognitive scaffolding (Rogoff, 1993). Thus, it is increasingly recognised that family members, peers; the media (Gatt et al 2008, Tunncliffe et al., 2008) are triggers in children begin developing an awareness of phenomena which are 'scientific'. Moreover, whilst children are experiencing and learning about science and building up their scientific repository from the earliest of years. The youngest of children observe think, investigate and act an intuitive scientists (Gopnick, 2009). Learning does not occur in a linear manner but in a constructive, sometimes referred to as a spiral curriculum context, being developed increasingly in more depth (Bruner, 1977). The starting point for science is observation. We consider that such process of acquiring such an essential foundation in the learning of science begins as a solo occupation, the child's *personal, spontaneous* science, then may develop further through a *partnership with someone or thing else* and finally may expands though the more formal or *designed experiences*. Children observe and try an action, such as a 2-year-old boy looking at a toy slide winding downwards in a spiral then, with no prompt from anyone, letting go a small ball down the ramp, again and again. These personal learners intuitively observe and investigate and make correlations. Practical hand on experiences play a key role in since learning for many, whatever age.

A visit to a museum may be planned a number of times during a child's school career in countries where this an accepted part of their curriculum. Denoff, Missouri and Osborne, (2005) identified three categories of motivation of year 9 (equivalent to 8th grade in USA

and about 14 years of age) cited by pupils and teachers on visits to the Science Museum in London as a school organized events visits for education and participation, less pupils identified it as a social event or a fun seeking experience.

Emergence of inquiry science from a child's earliest years and stresses the importance of play. Play is children's work! "Science, during early childhood, is more than play: It is serious business. If we fail our children and students in science, the reasons may include lack of appropriate experiences during early childhood" (Roth, Goulart, & Plakitsi, 2013).

Looking at science out of school

Traditionally science out of school has meant a variety of sites such as field centre, museums, science centres, zoo, and botanic gardens. Which are all venues where interactions that may lead to the construction learning (Vygotsky, 1962). Such experiences are frequently individual ones. However, the socio cultural aspect of learning became reignited as an important element of the learning process the latter part of the twentieth century, partially the work of Vygotsky. A genre of identifying the interaction of visitors with exhibits in outside of formal school institutions was developed following on the visitor's studies work of the mid twentieth century. In particular there were studies of tracking and timing visitors to find at which exhibits they expresses interest (Yalowitz and Bronnenkan, 2009), too analysing the conversational content. Tunnicliffe (1995) analysed conversation of both school groups and families at animal exhibits, live, animatronics and classic natural history museum taxidermic specimens. Ash (2003) identified dialogic inquiry occurring in dialogues of families at dioramas.

Classical museums have been regarded as places of objects but an understanding has developed in the beginning of the 21st century that museums are places where stories are heard, narrative authored and ideas emerge and are linked together with actual objects (Weber 2015) and 'museums' are indeed places where active interaction with objects can lead to learning further since built on a basic personal stock.

At natural history dioramas, a distinct genre of museum exhibit, (Tunnicliffe, 2013) visitors focus on observation, rather than physical manipulation; process skills such as inference come into play. Observing complex arrangements of objects in realistic dioramas demands specialized skills such as inference. Often, verbal interaction takes the place of physical interaction. This pattern is markedly similar to the way a naturalist visits a new ecosystem. It can be seen as an opportunity to put self into a novel environment that might not be seen otherwise (Ash, 2002, 2003).

Building an understanding of aspects of science

Traditionally, in the West, formal science was traditionally taught in a declarative manner with the teacher being the transmitter of knowledge and the learner regarded as the receiver. Many educational systems do still teach science in this way, if it is included in the young learner's formal curriculum at all (Patrick & Mantzicopoulos, 2015, p.15). Indeed, in the second half of the twentieth century educators increasingly acknowledged that learning is a two way process, There is a conversation of learning generated, between a source of information and instruction to a learner who already possessed a certain understanding gained from experience and previous 'instruction', the dialogue developed at a level appropriate for the learner to build their developing comprehension. As a result, learning became an important part of science education in schools. It gave rise to the development of inquiry-based science (IBSE).

Physical science and primary schools

An Important issue in considering physical science in particular is that many early years setting, the educators, be they carers or primary/elementary teachers, or chaperones on school field trips, are not confident in their own science understanding. Particularly, it seems, in that of physical science and the nature of science. Indeed, in a sample of primary schools by the Wellcome Trust, only 6 per cent of science subject leaders were found to have a degree containing any science (Wellcome Trust, 2013). Furthermore, it was stated in the UK Parliament in 2014 that only 8.3 teachers in primary schools did so. (Outlined in answer to House of Commons written question 218919,

<http://www.parliament.uk/business/publications/written-questions-answers-statements/written-question/Commons/2014-12-16/218919/>). Thus, it is not surprising that primary teachers feel uncomfortable with physical science. However, one of the authors of this chapter has found that offering workshops in professional development on physical science and animals can interest teachers and provides them with more confidence to tackle such topics as forces with their classes and look for applications. Hence looking at animals in zoos and museums is a different way of assisting children to understand some aspects of physical science in action. Furthermore, whilst increasingly it is recognised that there are 'Big Ideas' of science knowledge and that the curriculum should be narrowed from a broad uncoordinated content to one of greater in depth learning (Harlen, 2015), it is also recognised that science teaching of whatever kind should be applied to an everyday context (Harlen, 2015, p. 50.)

Inquiry science and development of knowledge

Emergence of inquiry science from a child's earliest years and stressed the importance of play. The stage of inquiry science from being directed through guided science to 'Open' or 'Authentic' science with the learner determining the plan, the action and the interpretation of outcomes, is discussed together with exemplars from observed real situations. School policy or individual audits in charge of a school visit hence occurring in a formal learning situation but in an out of school setting, who organised the visit, often have a policy for the assessment of the visits and outcomes of knowledge gained and how to record such. Inquiry science approach rather than a declarative one stresses the partnership between adult and child in the learning process. It is salutary to bear in mind in such two way or three way dialogues, if interpretation or other interventions from the museum are heeded, that for the child their ideas their personal interpretation in their to make sense. Their comments should be regarded as alternative conceptions to the accepted wisdom. In fact as Osborne, Bell and Gilbert pointed out (1983), that these ideas are children's science which is developed into school science in the formal education system and which may develop in some learners into scientist's science. The child is not wrong but making sense with their limited knowledge at the time. As educators we are required to assist the learner in their journey to the established science.

One-way in which to help learners construct further understanding is to ‘throw back a questions to them (Tunnicliffe, 2015 p. 171). Indeed, such is an aspect of argumentation, which develops further the inquiry approach by seeking for the person making a claim, such as, That is a lion, or asking if it is, and asking the person what is their evidence for such a claim, whist is it about what they are viewing that leads them to that conclusions? In other words they have to justify their claim. An example is the eight-year-old girl at the Rowland Ward Dioramas that were in the Natural History Museums London, where she interpreted the scene portrayed in the African Savannah dioramas in human terms. She said:

“This is desert. He [the giant sable antelope] is master of all the land and he [the wildebeest] is eating the grass and the big one [the giant sable antelope] seems to say ‘*You all obey me!*’ but one is answering saying ‘*No way. I’m not going to bow down to you*’. Maybe he [the giant sable antelope] only lets them have a certain amount of water?’ (Reiss & Tunnicliffe, 2011).

Socio Culture aspect of viewing natural history Dioramas

People rarely view dioramas, or other exhibits in silence. Tunnicliffe and Scheersoi (2011) refer to the ‘experiential space’ and remarking about what is seen is a common response to the exhibit. Singleton visitors seldom utter out loud but will comment to others near them and will make commentary when asked on what they observe and that which catcher shirr attention if rewetted to “*tell me the story of the diorama*”.

Hence, the concept of situational interest (Krapp, 2002) is very relevant to our work. It identified and developed ‘situational interest’, whereby the attention of a visitor was ‘caught’, (Tunnicliffe & Scheersoi, 2011). Postulated that the immediate surroundings of a diorama were and experiential space’ in which such situational intertie was able to develop. Once captured, this potential learning environment can be enhanced by the development of scaffolding initiatives, labels and other clue materials but also through dialogue with a person. Krapp (2002) proposed that once situational interest had emerged that this could develop into individual interest. However he proposed that such could only develop if an affective responses and concepts already held by the person came together.

Such observations lead to suggest that further mental acts of engagement. And the generation of such feelings in a visitor can lead to 'individual interest'. This may all occur without an individual uttering a word but engaging him or her in a silent internal dialogue. Thus it is important in a child's learning opportunities that educators share the observations and talk about such with their learners.

'Children, we now know, need to talk, and to experience a rich diet of spoken language in order to think and learn. Reading, writing and number may be acknowledged as curriculum 'basics' but talk is the true foundation for teaching' (Alexander, 2008 p. 9).

Some adults, teacher or another adult, lapse into 'instructional' mode at dioramas. Thus, missing an opportunity to develop the learner's thought skill in the science process, seeking to hear their articulated justification of their identification, for the case of animal species, is their claim.

A mother and her two daughters aged 4 and 5 at a Bison diorama in Academy of Natural Sciences in Philadelphia, USA.:

M: What are these?

G1: Buffalo. We saw two of them on a farm.

G2: I think they are 2 sisters and that is the Mom and baby.

M: Do they all have horns? I wonder what they feel like.

G2: Woolly!

M: Do you remember touching an alpaca?

In the company of other persons, teacher, parent, peer or museum educator or docent, or overhearing a comment from another group or even a trigger from an interactive 'label', conversations may develop. Bruner et al., (1956) and Bruner (1990) identified that constructing meaning is a social event and occurs between at least two people. We should remember that learners in childhood visit in the company of an adult, either a parent or an adult from an educational establishment. Their dialogues generated and stimulated by the diorama are forming a part of the visitor's voice and informed by their fund of knowledge,

mental models and experiences. Such dialogue can further develop inquiry and understanding through conversational interaction. Ash (2003) refers to this as dialogic inquiry and points out that there is a thematic content inherent in the dialogue generated, about the diorama or may develop into inquiry process skills being used in their structuring. The use of questions and ‘throwing back’ (Chin, 2008) the other persons’ response, in the case of formal school, visits if adopted by the teacher or chaperone could facilitate learning thought this scaffolding provided for the learner. This situation of support is what Vygotsky (1962) referred to as the Zone of Potential Development and comments and particularly open questions can lead to concept expansion by the learner (of whatever age). Developing a dialogue from the direct observations and other comments triggered by the observations of the diorama of learners may lead to learning of fresh information and comprehension.

Mother and daughters at a Beaver diorama, also in Philadelphia, developing a conversation from the initial observation of a child:

G: Look, a chipmunk, lake and look at the birds in the tree.

M: What else do you see? I think the beaver ate the tree. Where do they take the wood?

G: Girl pointed and the Mother said “it’s called a dam”.

G: There is a chipmunk.

M: We get chipmunks in our yard sometimes. Haven’t you seen them?

G: Walked to the Opossum Exhibit but stopped. That is a raccoon (pointing at white tail deer exhibit) and then walked on.

That is a bobcat (then walked on).

I can see opossums, lots of them and more over here.

A School group of 8 year old children viewing a diorama, in the Academy of Natural Sciences, featuring a puma:

G: Have you seen this? See the cat and mule deer (*she found the name glancing on the label*)

B: I think that is going to eat the deer.

G: I found its tail.

Of course the culture from which this learning audience comes is important. Learners must have the confidence and expectation that they may, to ask questions and not be inhibited in giving their response such as justification of their naming of a biological organism. However, the adults with children, or adult learners, need to allow the learner to inquire and not receive information in a declarative style, as this mother, informal them and close any dialogue that might be developing.

Many adults teachers chaperones with school groups or parents/cares/relatives on family visits, apparently see their role as disseminator of information transmitting such rather than encouraging the learner to think thus extending their repertoire of understanding. Thus, it is now acknowledged that the construction of knowledge is not solely a solitary individual affair but is very effectively by the dialogue of others around the individual. In a group one individual's' comment cues in that from another individual and together the group build a consensus learning. Teachers and other educators can play a vital role in scolding such dialogues in developing dialogic talk (Alexander, 2008).

An adult and a group of young school children are observing a puma again in Philadelphia:

B1: It is a tiger.

G1: Oh!

G2: There is a cat on a rock and it is night time.

G1: It is trying to jump on that animal.

G2: That animal is its prey.

G3 There are deer over here. They are called mule deer. (She read the label)

A: Ready to go?

In the above reported conversation the accompanying adult played no part until she decided that it was time for the group to move on although the group seemed as if they would continue their observations and comments. Whereas a group of 8 year old girls in the same gallery, observing a Pronghorn, generates an emotive dialogue after the staring comment of desire to be scared where she postulates imagery movements of the animal which has the instinct to eat her.

G1: I want to see some of the scariest things. Look, it is moving and trying to eat me. That is what I think.

G2: I think they are cute.

G1: I think they are all trying to eat me. I want to get out of here.

G3: I like the baby.

The social context in which a visit is undertaken is important. Visitor's reasons' for visiting museums including social and educational reasons which lead to create their personal agenda. The visitors agenda according to Missouri (1997) could be viewed as having two dimension I) the motive people have of visiting a museum and ii) the strategies people utilise when they finally visit the museum.

Tunncliffe (1995) found that the content of conversations at animals in museums varied according to the composition of the viewing groups. Namely, teacher- pupils, Chaperone - pupils or pupils only. Furthermore, the age and gender of the pupils also affects dialogue content and focus (Tunncliffe 1996 c).

Focus of visits

Visits which also contain a focus on with activities designed to be performed during a visit at exhibits, as well school based activities before and after a visit, are an integral part of the learning (Allard et al., 1994; Moretin & Guidisaloa 2014) as many museum educator know. Indeed, ZSL devised programs of 'zoo sandwich' in the early nineties whereby the visit was the filling. Well-designed visits with activities that can be done during the visit itself as well as pre- and post-visit activities to be done in the classroom and which are linked to the curriculum can considerably increase student motivation and teach (Osborne & Dillon, 2007). Natural history dioramas in galleries are not similar in exhibit terms to those hands on interactive in science centers. Tunncliffe and Scheerso (2011) point out that the focus of intervention initiatives should be at such on accurate minds-on observation rather than physical hands-on manipulation of objects and invite questions from the observer by his response to the dioramas.

Visitors attend museums, which by definition includes those with natural history dioramas with a variety of agenda, as a conscript taken by someone as part of a curriculum focused school visit or a family outing, or as a free choice learner who almost by definition has to be solo. The conscripts have made the visit predominately at the request of a companion or adult with a target. The visitors have been described as having a playing role (Falk, 2009) ready to ‘relearn’ what they learn or they once knew (Falk & Dierking, 1992). Falk (2009) identified also, five key motivations of volunteers museum visitors that are not being seen to the school groups. Moreover, visitors, particularly organizers of school visits, but also the ‘leader’ who initiated the family or leisure group visits, haven agenda before they enter the museum (Doering & Pekarzik, 1996). The visitors’ agenda differed regarding the personal interests and the content that they visit the museum. Theses consists of content on which to focus, time available, there may be a wide variety of objectives even within a group with a common overall objective as group members or even individuals in a family or couples vest may have many different agendas of what they want to see. Indeed, the rationale with which visitors come to the venue are known to directly influence their behaviour and learning (Anderson et al., 2008, Akertson et al., 2015).

Responses to dioramas

The social context in which the dioramas are viewed, the age of the learner and the motive for the visit all influence the way in which visitors respond to the dioramas. Visitors expect to see representations of the living world in natural history museums.

An English primary school group of mixed gender 8 year olds, visiting the Powell Cotton dioramas, accompanied by their head teacher, responded as follows.

HT: What’s that there?

B1: A horse

HT: Why do you say that?

B1: Because its got some ears.

HT: Like your ears or horses ears?

B2: Eyes and head, nose

B3: And bigger nostrils.

HT: What about that hair on its back?

B1: Hair

HT: Special hair?

B2: Horsehair.

G1: Mane.

Visitors expect that museum specimens in dioramas are static, unless they are animatronics, which adds a different dimension to observations (Tunncliffe, 1996 b) because the models have a cycle of movement, which is repeated and repeated. Visitors do however comment about the portrayed behaviors of the animals. However, not as many as those generated at zoo animals which were moving, but the pose in which the taxidermist had positioned the specimens enabled visitors to comment about the physics ideas and behaviors such as movement, feeding and fighting.

A 5 year old boy and a male teacher.

T: Look, It's an anteater (pointing at the exhibit). It has a long tongue and is sticky and it sticks it down on the ground and ants stick to it.

Clayton, a 6-year-old boy at the Gallery 2 (Kashmir diorama) at Powell Cotton Museum.

B: That one there's fallen down and that one going to eat it. I am a buffalo. He (referring the animal near the falling animal on top of the cliff) wasn't sure if they just jump. There is an eagle. You can see animals everywhere.

However, it seems that because the narrative generated spontaneously in front of dioramas is so rich and visitors spend time describing the depicted scene, naming the animals and commenting on their appearance, not as many actions are described as in front of standalone specimens in natural history museums. This behaviour, it is suggested, (Tunncliffe and Scheersoi 2011), is that visitors respond to dioramas with distinct patterns of behavior. Initially they identify the specimen and name it and often comment on a salient feature or structure, but at dioramas, they also describe behaviours and make affective comments. If their interest is caught, they start interpreting the scene presented, mostly in anthropomorphic terms, seeking to relate the subject to what they know and

understand. Visitors rarely read the information provided by the museum (texts) and interpret at the level of their biological knowledge, which is generally basic. They may raise questions about the subject, ask why, how and what and construct hypotheses. In most cases, this typical biological dioramas interaction sequence occurs: identify – interest – interpret - investigate (Tunnicliffe & Scheersoi, 2011) however, the order of these four typical activities may vary. If, we suggest, the constituent contents of a diorama are analysed, appropriate minds and related simple hands on activities to assist learner in interpreting the scene portrayed and learn about the science illustrated in action.

The first task is to identify and interpret with the scene portrayed. A person's attitude towards and understandings of the environment are profoundly shaped by their attitudes towards, experiences and understandings of living organisms' (Reiss & Tunnicliffe, 2011). However, Children brought to a museum under the auspices of a school outing are essentially conscripts (McLaughlin et al., 1998, Lawrence and Tiknkler, 2015) and, although there may be free choice 'learning' (Falk & Dierking, 1992), some of the visit is focused on a topic, which is chosen by the teacher and aligns with the curriculum of the class.

Children are creative thinkers recent research (Robson, 2014) has developed an approach, which it refers to, as the ACCT framework, (Analysing Children's Creative Thinking) to identify and also analyse this in young children. It identifies that creative thinking based on prior knowledge, which is evident in the interpretation of a scene in a diorama by visitors of all ages but particular in children. For instant, a twelve-year of boy, looking at a Savannah dioramas in Gallery 3 at Powell Cotton Museum (See fig. 1) made this comment, *'Party! Everybody, loads do animals everywhere and wolves, deer, bears eagles flying squirrels buffalo and there's a war between all of them. So that's why they are all over here!'*

Older visitors often are reminded of past events in their own lives, such as the retired midwife who looking at the same diorama remarked *'I think dioramas are fantastic and feel like I am back in Africa again so this takes me back. Today started off well and now*

has got better. It's all so accurate, so reminiscent of what I saw many years ago when we went to live in Africa in Zambia close to Rhodesia. I was a midwife just after independence'. The lady moved to the next diorama (The Watering Hole Diorama) and continued 'Just think it is absolutely realistic. Actual environment of each are so very realistic, seeing them got me! It makes the animals look more scary we went to the area called chucuna near the Zambia and Rhodesian border and stopped the car and out of the bush came an elephant [looked at large diorama] just like that one, I was angry, we started the car and left. Absolutely amazing I worked as a midwife, most patients came from the bush and were so vulnerable, and treatment differed from that which they got back in the bush'.

Insert FIG 1 photo of African Jungle Diorama, Gallery 3

Whatever in summary children are taken to look at animals they, as well as the person organising the visit have agenda. These consists of:

- Content
- Time
- Cover a wide variety of objectives

They have many different missions and their rationale with which visitors come to the venue are known to directly influence their behaviour and learning (Anderson, Piscitelli & Everett, 2008).

Learning everyday about Science

Children do not begin their formal school careers knowing nothing of science, whatever age they begin this formal learning journey, which varies from country to country. In pre formal school in countries such as England many children attend preschool at 3 years of age and in some part nurseries take children in their first year and offer sessions for an adult and children of 2 year old to 'Stay and Play' (Lloyd, in press) where activities offer science learning experiences in the activities. If you observe young children at play they are purposeful in their 'work'. They investigate, ask question to themselves and try out strategies apparently to 'see what happens' and they explain what they obsessive in their own terms from their existing knowledge. Importantly, they do not held the concept of 'success' or 'failure' in their own vocabulary. Whatever they discover either works the

way they thought it might, or it might not and they learn from that. 'Failure' is not in their world. That is something doesn't 'work' is.

Psychologists assert that aspects of science are learnt in different domains, one for biology and one for physical science. Moreover the ideas of child about what scientists identify as physical science are different from those of scientists, hence being children's science (Hadzigeorgiou, 2015). Children of different ages, and thus different stages of cognitive understanding, interpret phenomena differently. Their 'common sense' ideas are modified as they acquire new experiences and make their own observations as well as accommodating into their mental model information and explanations received by them from a variety of sources, including teachers once they are in formal education. Driver et al, (1985) suggested that the claims of young science learners are similar to those of earlier societies and the people of, particularly western European. These ideas developed in the advent of scientists who made their pronouncements based on evidence with often suffered for it, as for example did, **Galileo Galilei**, in the Renaissance in Western Europe. Whilst developmental psychologists discuss the process of learning sciences, biological science appears to be an exception to the accepted idea that children learn and are in agreement that conceptual development is a specific construction of the physical world and they use what Inagaki and Hatano (2008) refer to as personification. As the learner interacts with their environments they find patterns and build up a store of knowledge as past ideas are modified and developed in the light of further understanding.

Through interpretation of observations made rather than explaining phenomena by religious doctrine and traditional folk science. Such ideas are modified as learner develops assimilating fresh understanding and often downgrading the former explanations but these mental models are applied regularly and some do not change even in adulthood, particularly if they have not encountered any further information. For example, a group of mothers at Sreepur Village, Bangladesh who had not received schooling and were attending a session of 'everyday Science' were adamant with their explanation of shadow formation. That shadows are explained thus "*Sunray comes from the sun but sometime the*

sun swallowed the earth. Because Sun is grateful to the moon. That's why earth become dark sometimes" (Translated from the Bangla by Angshuman Sarkar science facilitator). We should also bear in mind too that science understanding, and motivation for learning, changes from year to year especially once in formal schooling. Children of different ages and thus different stages of cognitive understanding interpret phenomena differently. Their 'common sense' ideas are modified as they acquire new experiences and make their own observations as well as accommodating into their mental model information and explanations received by them. Thus, the same question asked to say 63 years old, 6 years old and 10 years old is likely to be answered differently (Gouskou & Tunnicliffe, in press).

Developing biological awareness

Biological awareness and interpretation however is unlike other aspects in this world of a child in which they are constructing their knowledge and interpreting the world in their terms, indeed constructing a 'children's science'; as opposed to what they later encounter as 'school science', which again may lead onto further understanding through teaching and experience and reflection of the learner, are not 'misconceptions' as defined by teachers well versed in the school and scientists science, veers to understanding 'scientists science' (Osborne, Bell & Gilbert, 1983), referred to by some researchers as 'naive theories, or alternative conceptions (Driver et al. 1985) It is argued that young children have the ability to acquire viable realistic concepts of the living world when involved in relevant activities where they are instructed. We argue as teachers that, children through their own observations construct an understanding from their own experiences. If you observe what catches the interest of young children they make acute observations. Moreover, researcher's emphasis and teachers know that children have intimate experience of aspects of the biological domain, they are living in it and that their knowledge of particular mammalian functions is different to that of other domains because aspects are so personal because they are a biological organism. Thus young children explain phenomena through applying thus 'such personalization' explaining biological phenomena in personal terms and the more similar the target for interpretation is to the human, which is themselves, the easier it is to apply similarities to themselves to interpret that which they observe or are asked. Such use of the self as a template was explore extensively by researchers such as

Susan Carey (1985). Hence, the use of anthropomorphic explanations or example when visitors of all ages interpret animal behaviors when looking at animal exhibits (Patrick & Tunnicliffe, 2013). However, whilst children have some everyday knowledge of everyday animals and plants (Patrick & Tunnicliffe, 2013) they know of some no endemic animals such as lions and rhinos from media sources they have more restricted knowledge of plants (Gatt et al., 2007). Cacti, trees for example were not recognised as plants, which is word, used by young children synonymous with flowering plants. It follows that when looking at natural history dioramas too, visitors interpret that which is noticed in a similar way. Cognitive psychologists however regard Scientist's science as belonging to a different domain.

Recognising Physics in action

Physical science concepts are acquired in different psychological domain and hence different to biological concept (Inagaki and Hatano, 2008). A domain is identified as sets of phenomena, which learners interpret using 'children's science' and enable the person holding them to explain such. As it is believed that these learners acquire their biological interpretation, some physical phenomena, during early childhood are given biological explanations. Young children assumed moving objects are endowed with biological powers such as movement at will. The possession of life is attributed to physical phenomena such as clouds and fire. The forces associated with movement are important and movement is one of the characteristics of animals and early pre secondary aged children it as a defining one (Tomkins and Tunnicliffe 2007).

People rely on the content of their mental models to name or identify that which they are observing. This work following described here is a preliminary attempt to find if children can identify in the natural history dioramas any manifestation of physical science in action. Of particular interest is the topic of forces, which learners have difficulty in separating for the idea of motion. Balance and centers of mass in action may be observed, particular in arboreal animals, such as the primates in the primate dioramas at Powell Cotton museums

(Fig 2). Light, sound as well as movements and adaptations opt the environment in which the featured organism naturally inhabits can also be identified.

Insert Fig 2 Close up of Primate Gallery (Walking on branch and sitting one on branch).

Observing natural history dioramas spontaneously and then cued, provide opportunities to identify physics in action, albeit at ‘a moment frozen in time’ as Reiss and Tunnicliffe (2001) describe in a Museum of Scotland diorama shows a pair of wolves frozen in their chase of a wild boar in a Caledonian pine forest.

Most animals, when alive, can make some observable movement and most possess the power of locomotion - being able to move from place to place. Balance and centres of mass are phenomena which can be observed in natural history dioramas, as well as structures to bear the mass of the animals, ice, appendages, particularly legs in land living animals such as the elephant or rhino (as shown in Figure 1 African Jungle diorama), and inquiring when the legs of these animals are much bigger in diameter than arid those of the antelopes or indeed the giraffe. Such serrations can lead to surface volume ration understanding and the needs associated with being warm blooded and main gaining body temperature. Observations the most effective position for the legs can be developed into the position of legal on the torso in quadrupeds and then in bipeds and the issue of how animal maintain an upright stance when for example, begin to drink. This is show by the position of a giraffe in the ‘Water hole’ diorama in Gallery 1 at the Powell Cotton Museum. Discussing how the leopard in the corner of the Savannah diorama in (manages to haul up his prey to his rocky perch.

Insert Fig. 3 The Watering Hole Diorama

At the Kashmir diorama in gallery 2 of the Powell cotton a boy exclaimed, “*Look, See! At that animal, he’s fallen off the wolf’s made him fall off*”. A goat is depicted falling from

the top of a cliff where they're a wolf as well). An observation such as these would pray an opportunity to discuss further gravity and forces.

Insert Fig. 4 Kashmir Diorama

The Galleries of Powell Cotton Museum

Gallery 1 is displaying the animals of north and West Africa and India. Today, this is the first gallery visitors see on entering the museum but it was actually the last gallery built by Percy Powell-Cotton himself, being completed in 1939 the year before his death. The large diorama to the left is known as 'The Watering Hole' represents many species from across northern Nigeria and Chad. The central diorama showcases the amazing diversity of Africa's primates and the different landscapes they live in. The diorama to the back right of the gallery depicts animals from the Indian state of Madhya Pradesh (which translates as 'Central Province'). The final diorama, to the right of the gallery, incorporates a variety of landscapes and animal habitats. The far left represents the more lush woodlands around the Mkuze River, in northern KwaZulu-Natal, South Africa. The central part of the diorama, formed of a high rocky crag, represents the Ethiopian Highlands, an area where land levels rarely fall below 1500 meters. The Mountain Nyala displayed here, are only found in this region and have become a rare and endangered species. Finally, the desert habitat at the front of the case showcases the diversity of species found in the Sahara desert (Powell Cotton Museum Gallery 1, (2015). Retrieved from <http://www.quexpark.co.uk/museum/museum-galleries/gallery-1.html>).

Gallery 2 called 'The Pavilion' was the first gallery design and build by Percy Powell-Cotton and the starting point for his relationship with the taxidermist Rowland Ward, who helped build and design the museum's famous natural history dioramas. (Powell-Cotton Museum Gallery 2, (2015). Retrieved from <http://www.quexpark.co.uk/museum/museum-galleries/gallery-2.html>). Gallery 3 was the second gallery to be built, added on to the 'Pavilion' in 1909. The dioramas in this gallery focus on species from equatorial Africa and the plains at the edge of these forested areas. Retrieved from <http://www.quexpark.co.uk/museum/museum-galleries/gallery-3.html>). Galleries 2 and 3

equally have the science potential to explore physical concepts but they did not used at this present pilot study.

The following table (see Table 1) is a summary of some of the physics concepts that are illustrated in the dioramas of Powell Cotton. For example, gravity and forces in balance of animals and the position of the legs especially when the neck is bent toward a water source. Linking biology with physics for maple, ether are members of the two toed hoofed animals, ungulates (Artiodactyl) their weight is two toes, the third and fourth, which form the hooves. The one toed, or odd toed, ungulates, (perissodactyls), have their weight carried through the by the one hoof. The various physics principles, which are manifest in the animals, are listed below. They can be identified in looking at any animals, live or mused animals but are particularly effective to notice in a natural bestiary diorama where the animal are exhibited inaction in a realistic context.

A guide to the Physics concept of the Galleries of Powell-Cotton Museum*

Gallery1

Diorama	Physics Ideas	Animals
The Watering Hole		
	Camouflage	Bongo (stripes), Zebra
	Stripes	Mongoose
	Countershading	Oribi
	Pattern / sunlight	Giraffe
	Colour blending	Antelope
	Flight (forces)	Butterflies
	Reflection	Oribi
	Centre of gravity, spreading load	Giraffe
	Stray legs/ heavy animal	Buffalo split hoof wider surface area sand
	Thin legs light animal	Gerenuk (on 2 legs)

	Position of legs	quadrupeds
	Heat loss	Fur
Indian Forest		
	Stripes	Tiger
	Foes pull	Sloth bear claws
	Forces (gravity)	Leopard & antelope in the tree
	Push	Porcupine spines (also adaption of fur/hair)
	Gravity	4 horned antelope off ground(leap up and down)

Table 1: The Watering Hole and the Indian Forest dioramas

Diorama	Physics Ideas	Animals
Primates		
Balancing	Balancing: Walking on branch	Central African red colobus, moustalled monkey
	Balancing: Sitting on the branch	Black and white colobus
	Balancing: standing by tailing	chimpanzee
	Communication	Gelada baboon, theropithecus gelada

Table 2: The Primates

Diorama	Physics Ideas	Animals
North Africa		
	Camouflage	Addax

	Camouflage (different version)	Red neck gazella
	Balance (Tee toe)	Addax
	Colour blending	Antelope

Table 3: The North Africa dioramas

* These are only some examples of the potential of introduction of basic physics.

Some museums have made an active effort to involve visitors with the content of their dioramas by providing artefacts related to the narrative in front of the dioramas so visitors can not only mentally interact and interpret the narrative but also physically. **The Panorama at the University of Kansas Natural History Museum**, a 120-year-old, nearly 360-degree-view diorama that embodies a historic first in the representation of nature for the public has introduced such physical action interpretative items. This iconic exhibit represents ecological regions extending from the Arctic coast through North America into tropical rainforest. These include two interactive stations with touchable objects (see Figure 1), and activities in museum discovery guides Personal communication MacDonald, 2015).



Such action labels leads into the pilot studies conducted at the Powell-Cotton Museum in England to explore the spontaneous recognition of physical science in action in the dioramas and whether this could be increased by trigger workshops to refresh primary school children of science concepts they had studied.



Two pilot studies were undertaken; one with two 11 year old boys who had studied science at their state school and were frequent visitor to this museum. The other group was 15 mixed gender and ability 8-year-old children, half of whom had visited the museum previously and half who had not. Museums in the United Kingdom run courses for parties of school children, as do zoos and botanical gardens. The majority of such are linked to the topics required to be studied in state schools relevant to the national curriculum of the country of residence.

The two boys were invited, each with a researcher, to look at the Watering Hole diorama

(FIG) and tell us “looking at the diorama, what is it about?” Their response was of observations made with some inferences. Boy 2 replied, “Desert. Wild variety of animals doing all kinds of things. A giraffe reaching to eat. Different species of animals. Different zebra animals, doing different things as a group”. Boy 1 was interested in that, “this diorama puts together animals in the same space. The diorama is like it combines different animals in arrangement for the visitor.”

His response to “Where are the things you notice?” was about the effect of the dioramas. He commented, “It’s a freeze framework of the wild, a short image, very impressive, they also have created the background representation of the wild.” Whereas Boy 2 replied, “leaves and animals and it really seems I am there and this makes the difference (to learning science at school)”. The responses to what were the animals doing were factual and descriptive. Interest was expressed by Boy 1 in the movement of animals portrayed but with sensitive interpretation of positions, he highlighted one antelope that was looking back over their shoulder “as if she’s lost something and she looks round to spot it. The antelope’s attitude is like a tourist’s attitude in a new place when confused.”

Workshop in middle of visit.

In another room the boys were introduced to the ‘equipment’ for a workshop, namely modeling clay and some small sticks (cocktail sticks) to represent legs. They were asked to make animal that could stand upright stably with 4 legs. One boy immediately made a horizontal rectangle shape and fixed 4 lags one at each corner of the body. The other boy decided to make a 4-legged animal with a vertical cylindrical body. This was resistant to standing up! He eventually decided to reorient his 'body' so he had rectangular one lying horizontally. Then he fixed the kegs together in the middle of the underside of the 'body'. Eventually he decided to try positioning the legs at corners and was pleased that this produced a stable model. The boys were invited to stand their ‘animal’ on a pike of card which acted as a ‘wobble ‘board and to investigate for how long their animal stood as they recued more and moa backward and forward movements of the broad. They found that by having the legs not coming down vertically from the body but at an obtuse angle, slanted, the model animal s were more stable. The boys were asked model to add neck and head on their ‘body’ and then show how the ‘giraffe -like model animal could drink. By

simulating it visiting The Water Hole, modeled in the diorama (Fig. 3). They found that the animal tipped over until they had made the area between the legs wider and shallower. They remembered they had learnt about forces in school science but said it had not related to anything in their everyday world, like animal movement.

On returning to the diorama the boys added these inherent science ideas of balance, stability and centre of gravity to their interpretation of the diorama. Boy 1 reported that “the giraffe starts bending her legs to get her head closer to the ground. I can see stability in the animals. The legs support the position of the head. Each part of the body supports because, for example, one leg of the giraffe cannot work with the other legs.” He noticed the information provided by the body of the animal; the spreading of legs increasing the surface area underneath, spreading their weight on their legs and nobody standing on one leg.

Boy1 showed with his own body, how an animal altered the position of its legs in order to bend down to drink and not overbalance. He was intrigued identifying animals that were bending down. Boy 2 also noted that the buffalo had wide legs and the antelopes had thin stick legs. He also postulated that animals with big ears, such as the Bongo, could hear better and needed to because it was dark in the rain forest.

They had also been asked to balance on one leg as a starting activity and were intrigued, particularly looking at the Gallery 1 The Watering Hole diorama (see fig. 3), to now notice that animals sitting on branches must be balanced and had to walk one leg in front of the other along a huge branch. Moreover, the study shows that children can identify science in action in animals. Thus in addition to the usual workshops on biodiversity and conservation, basic physical science has its place in natural history museum education.

Peer groups response to dioramas and the effects of a series of simple workshop activities with the 8 year-old children resulted in a greater awareness of the science in action in the dioramas. The activities tried were: making four legged animals from modelling clay and looking at balance and stability and matching colours of cards to colours in the animals (see Table 4).

A Group of 8 year olds activities in the gallery

Peer group responds to dioramas and effects of a series of simple workshop activities with the 8-year-old children resulted in a greater awareness of the animals in action in the dioramas

The activities tried were:

- Making 4-legged animals from modeling clay and looking at balance and stability.
- Matching colours of cards to colours in the animals. (Designed for early years)
- Identifying basic mathematical shapes (designed for early years)
- Walking the line on tip toe (balance).

Laminated cards of the outline of simple geometric shapes enabled the children to find the basic shape in the animals and name the animals. Table 4X

The responses of x 3 groups of 8-year-old primary pupils to the colour matching activity and a shape matching activity are presented at the Tables 4 & 5 below.

Colour	Animals		
	Boys Group	Girls Group	Mixed Group
Pink	Giraffe tongue	Gelada Baboon, Gorilla's mouth.	
Red	Baboon	Gorilla's eyes	
Beige	Donkey, Addax, Dorcas Gazelle	Western Lowland Gorilla	Gazelle, Ass, Oryx.
Brown	Swaynes Hartebeest, Roan Antelope, Beetle	Porcupine, Mona Monkey, Bush Pig, Addax, Talapo, Guenon, Zebra, Gorilla's teeth.	Suni, Lechwe, Wildebeest, Giraffe.
White	Black and white Colobus stripes on the Nyala.	Colobus Monkey.	
Black	Sloth bear, Bush hog, Cape Buffalo, Monkey.	Bear, Gazelle's horns, Udad's horns, Colobus Monkey, Chimpanzee, Gorilla, Bush Pig, Cape Buffalo	Gorilla, Buffalo, Chimpanzee, Colobus, Hog, Boar
Orange	Crab	Tiger, Leopard	

Black and white stripes	Zebra, Beetle, black and white Colobus, Tiger face	Zebra	Zebra, Colobus
Cream with brown splodges	Giraffe, Cheetah	Giraffe	

Table 4: The response of boys, girls and mixed groups to the Colour activity.

Also, laminated cards of the outline of simple geometric shapes enabled the children to find the basic shape in the animals and name the animals (see Table 2).

Shape	Animals		
	Boys Group	Girls Group	Mixed Group
Circle	Eyes, pond, leaves, Mrs Grey's Lechwe	Eyes, Sloth Bear's head, Hyena's nose, Buffalo's nostrils.	Monkey's faces, Monkey's noses, Tiger's feet, Nest.
Semi Circle	Zebras, ears, bananas.	Gazelle's nose, Tiger's ears, Buffalo's legs.	Hooves, bananas, claws, Monkey's nose, Ass' nostrils, Animal's nostrils.
Oval	Leaves, Deer's body, eggs, Mongalla Gazelle.	Buffalo's ears.	Boar's nose, leaf, noses, bodies, ears, faces, eyes, Beetle, Tiger's tail.
Cylinder	Giraffe neck, tree branch, nest, legs, horns, Monkey torsos.	Buffalo's legs.	Animal's legs, feet, tree, horns, tails, paws, claws, bananas.
Rectangle	Monkey torso, head, rocks.	Edmi Gazelle's body, Sloth Bears claws, Baboon's foot, Bush Pig's leg .	Rocks, bodies, Ass' body.

Table 5: The responses of boys, girls and mixed groups to the Shape activity

Finally, the museum educator had constructed a long 'line' out of thick paper and inch wide, which was adhered to the floor. Children were asked to walk along it normally, finding they had to put one foot in front of the other to stay on the line, and then on tip toe and keep their balance. Children found that when walking on tiptoe they needed to use their arms in order to maintain their balance.

Our Lesson

The lesson that emerged from these preliminary workshops that is primary science is not taught within a meaningful context in primary schools. Once primed after a viewing by activities the children on a second viewing were able to identify science in action.

Conclusion

Physical science principles are implicit in observing the living world and these life sized representations of a moment in time, whether a faithful representation of a known scene or a conceptual construction diorama illustrating biogeographic principles, provide such an opportunity. School science, in the primary school at least, is not taught within a familiar context for children and they do not use school-learned knowledge in interpreting in this case natural history dioramas until they have been cued into the science concept with some 'hand-on' activities.

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