

HSCi Physical Science Learning Opportunities at Natural History Dioramas

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Abstract. Traditional view of science museums is that they present a static image of science, a fixed body. Visitors to museums come with pre-existing knowledge and frequently interpret that which they see but particular through using their own understanding referring to the labels and other interpretative means not only through the information provided by get museums. Such understanding is based on everyday beliefs. Listening to visitors in natural history museums reveals that few comments are made about science in action but focus on identifying the specimens and commenting on the attributes of the animals. However, physical science is much in evident in these animals although not focused on by natural history museums. I report here the effects of a hands on workshop provided for two 11 year old boys and separately to 8 year old primary children at natural history museums in the south of England. The specimens are displayed don an authentic context in natural history dioramas. The two dioramas focused upon was one of an African Savannah scene with a water hole and at the edge of a forest and a compilation exhibit of primates on rocks and trees. The children were asked to view the main diorama and point out any science that they could recognise. They participated in hands on workshop focusing on forces, balance and stability. The learners returned to the dioramas and were asked to again any science concepts they could see illustrated by the animal. After the cue provided by the hands on workshop they recognised a number of physical science concepts illustrated by the position in which the animals had been posed. Science in school for them had not been taught in a context.

Keywords. Museum, science, diorama.

1. Introduction

Numerous studies claim that the lack of interest in scientific and technological matters

lies in how the related contents are presented to the students [1]. Typically, traditional teaching is focused on master classes with the only support, in the best of cases, of closed and highly structured laboratory practices. Even for those students with an optimal profile, academic performance can be impaired by this merely conceptual teaching approach, standing far away from the ideal academic use of the scientific method [2,3,4].

In contrast to these traditional methods, there are several educational options, which have proven more beneficial and have thus gained increasing importance in recent years. Among them, the so-called Project-Based Learning (PBL) [5] can be outlined, applied for instance to experimental learning objectives. In our subjects of Physics of the first courses of Engineering University Degrees this technique has been used, proposing the students a semester challenge of designing, constructing, and documenting a hands-on activity that illustrates a concept, a law or an application related to the subject theoretical contents. The objective envisaged is to place the students in a non-academic situation outside the classroom, facing the resolution of a practical problem that will enable them to acquire the related transversal skills of our Engineering University Degrees, since the successful achievement of a final project of this type requires, among others, autonomous skills related to team organization, information search, discussion, experimental development and documentation.

The most outstanding results are afterwards gathered and shown in our web of reference [6], that can be used in our daily practice to support teaching, as a training tool for novel and senior teachers or as an open source of information for informal learning. This paper presents the main results and evaluations of the process of creating the contents of this website, representing the result of cooperative and collaborative work of students and teachers, unique in this category to the best of our knowledge. Many primary school teachers and museum educators are not confident in teaching physical science and the nature of science. Thus, it is not surprising that primary teachers feel uncomfortable with physical science. However, understanding is not only acquired classroom; it can be kern in a variety of places [1]. Furthermore, we now understand

learning occurs in other places and with other people as well as school and teachers. The context is an important factor in learning and recognise that family members, peers, the media are an influence on recognising and experiencing everyday science [2]. The youngest of children observe think, investigate and are intuitive scientists [3]. Learning is a constructive gradual accumulation as more is learnt [4-5].

2. Field trips

In the latter part of the 20th century onwards, there has developed 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 [1]. 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 [6]. Such experiences are frequently individual ones. However, the socio cultural aspect of learning became reignited as an important element of the learning process at the latter part of the twentieth century, particularly the work of Vygotsky.

3. 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. 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 [7].

4. Developing biological awareness

Biologists understand that the starting point for science is observation, [8]. The child's

personal, spontaneous science which they develop for themselves develops further through a *partnership* with someone or thing, and then through the more *formal* or *designed experiences in school*. If you observe for example, a 2-year-old child sitting on a stationary swing gradually work out; if there were no one to push him realise he has to generate their movement themselves! These young learners intuitively observe and investigate and make correlation.

Biological awareness and interpretation however, is unlike other aspects. In this world of children 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' [9], referred to by some researchers as 'naive theories, or alternative conceptions' [10].

5. Interaction - minds on with exhibits

Visits which contain a focus on activities designed to be performed during a visit at exhibits, as well as school based activities before and after a visit, can be an integral part of the learning [11-12] as many museum educator know.

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.

A genre of identifying the interaction of visitors with exhibits in outside of formal school institutions has been 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 [13] and analysing the conversational content. Tunnicliffe [14] analysed conversation of both school groups and families at animal exhibits, live, animatronics and classic natural history museum taxidermic specimens. Ash [15]

identified dialogic inquiry occurring in dialogues of families at dioramas.

Emergence of inquiry science from a child's earliest years stresses the importance of play [16]. The stage of inquiry science is being directed through guided science to 'Open' or 'Authentic' science with the learner determining the plan, the action and the interpretation of outcomes. Inquiry science approach declares 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, that for the children their ideas their personal interpretation are their attempt to make sense. Their comments should be regarded as alternative conceptions to the accepted wisdom. In fact, as Osborne, Bell and Gilbert [9] pointed out, these ideas are children's science which is developed into school science in the formal education system. Such school science may develop, in some learners, into scientist's science. We refer to the child's early ideas and explanations as "My Science". As educators we are required to assist the learner in their journey to the established science.

One-way to help learners construct further understanding is to 'throw back a questions to them' [17]. Indeed, such is an aspect of argumentation, which develops further the inquiry approach by seeking for the person making a claim, such as statement, "That is a lion", or asking if it is, being asked what is their evidence for such a claim?. What is it about what they are viewing that leads them to that conclusion? In other words they have to justify their claim.

Learners must have the confidence and expectation, 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, also need to understand the scaffolding process of learning from their not being declarative but questioning to develop the child's thinking. This is a role, many adult and teachers find difficult.

Schools and family visits whose spontaneous conversations has been analysed [18]. Whilst, the expectation of such a visit inks that museums' specimens are static, unless they are animatronics, which adds a different dimension to observations [19] because the

models have a cycle of movement, which inks repeated and repeated.

This research found that visitors comment about the behaviors of the animals. However, not as many comments were heard as those generated at zoo animals which were often moving. The pose in which the taxidermist had positioned the taxidermic specimens enabled visitors to comment about the physics ideas and behaviors such as movement, feeding and fighting.

Children brought to a museum under the auspices of a school outing are essentially conscripts [20] and, although there may be free choice 'learning' [21], some of the visit is focused on a topic, which is chosen by the teacher and aligns with the curriculum of the class. The varied foci depend on phase of visit [22]. Families usually have a different rationale for a visit.

Our work is concerned with the identification of that which children notice spontaneously of physics in action in natural history dioramas and developing relevant activities which can develop their understanding of basic physics.

It is our professional opinion that 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.

Other science phenomena such as earth science in the geology of the habitat or the weather portray science such as forces are evidenced and examples of physics concepts in action. Very basic ideas such as shape, size, colours, patterns and forces and balance can be observed. Floating and sinking, flight is other physics phenomena observable if animals are exhibited in a planned position, which shows such actions. Sound and light are important to living things for survival. Animals have observable adaptations, which utilise the occurrence of light and sound to their environment. However, learning strategies to focus attention of manifestation of physics in biology as observable in the dioramas, involves the educators knowing the foundation knowledge that the children possess.

6. Method

We decided to elicit primary children's understanding of physics and whether these learners could identify physics phenomena in action in animals at a natural history museum in the south of England which focuses on African and Indian dioramas. We collect and then transcribed transcripts dialogues in workshops and at the dioramas were collected and analysed through a read re-read iterative process, 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.

7. The research venue: 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 Madya 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. Retrieved from [23]).

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. The central diorama represents a lion and a buffalo, locked in battle.

The large diorama of animals from equatorial Africa include one of the most impressive specimens is the large bull elephant to the left of the case. In the same case is a truly rare sight – a group of Northern White rhino (*Ceratotherium simum cottoni*) (see Figure 2). (Powell-Cotton Museum Gallery 3. Retrieved from [24]).

8. Recognising Physics in action at dioramas

People rely on the content of their mental models to name or identify what 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 museum (Fig 1). Light, sound as well as movements and adaptations to the environment in which the featured organism naturally inhabits can also be identified.



Figure 1. Gallery 1 of the Powell Cotton Natural History Museum. Copyright Nikhilesh Havel. Reproduced courtesy of the Trustees of the Powell-Cotton Museum

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 [25] 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, eyes, appendages, particularly legs in land living animals such as the rhino (as shown in Figure 2), 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.



Figure 2. Gallery 3 of Powell Cotton Natural History Museum. 'The African Jungle' diorama. Copyright Nikhilesh Havel. Reproduced courtesy of the Trustees of the Powell-Cotton Museum

The 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, but are particularly effective to notice, in a natural bestiary diorama where the animal

are exhibited inaction in a realistic context.

PHYSICS IDEAS	ANIMALS
Camouflage	Bongo (stripes)
Stripes	Mongoose
Countershading	Nylah
Pattern / sunlight	Giraffe
Colour blending	Antelope
Flight (forces)	Butterflies
	Vulture, wings, talons beak, force
Aerodynamics Lift Bernoulli effect	Kingfishers
Centre of gravity / spreading load	
Hooves splayed (Even-toed ungulates)	Addax (white antelope)
Balance Thin legs- light animal	Gerenuk (on 2 legs)
	Donkey split hoof) wider surface area sand
Position of legs	Quadrupeds
Heat loss	Fur

Table 1. The physics concepts illustrated in Galley 1 with the relevant animal identified in the 'Water Hole' diorama

9. Two pilot studies

Such action labels leads into pilot studies conducted at Powell Cotton museum in England to explore the spontaneous recognition of physical science in action in the diorama; 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 visitors to this museum/. The other group was 15 mixed gender and ability 8-year-old children, half of whom had visited the museums 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 of the relevant national curriculum of the country of residence.

The two boys were invited, each had a researcher with them, to look at the main African diorama (and tell us, "Looking at the

dream, what is it about". Their responses contained some inferences made using their observations and previous knowledge. Of 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'*. This boy 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 " The movement of the animals,...is like you have a *you tube video and you have press pause*. All the actions have put together and this scene shows all the movements. They are represented as being alive. They animals are pleased perfectly to demonstrate that we have mention in the activity". 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 and focused on the species and other exhibits. Interest was expressed by Boy 1 in the movement of animals portrayed but with sensitive interpretation of positions, he highlighted that one antelope that was looking back over he shoulder, *'...as if she's lost something send she looks round to spot it. The antelope's attitude is like a tourist's attitude in a new place when confused.'*

10. 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 legs 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 more 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 animals were more stable. The boys were asked to add neck and head on their 'body' and then show how the 'giraffe -like model animal could drink. By simulating an exhibit in the 'Water Hole' diorama (see Figure 1) 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 used these inherent science ideas balance, stability and center 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 and for example one leg of the giraffe cannot work with the other legs'*. He noticed the information provided by the body of the animal and explained that the spreading of legs increasing the surface area underneath a spreading their weight at their legs and nobody standing on one leg.

Boy1 modeled with himself how an animal altered the position of its legs in odder to bend down to drink and not overbalance. He was intrigued identifying animals, which were bending down. Boy 2 also noted that the buffalo had wide legs and the antelopes thin stick-like legs and 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, particular looking at the 'Water Hole' dioramas in Gallery 1. The boys accomplished this task by observing how the animals sitting on branches and how they balanced by walking along the branch. Moreover, the study shows that children can identify science in action in animals. Thus, in addition to the usual workshops of biodiversity and conservation,

basic physical science has its place in natural history museum education.

11. 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 science 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).

ANIMALS			
	Boys group	Girls group	Mixed group
a	Giraffe tongue	Gelada baboon Gorilla's mouth	
b	Baboon	Gorilla's eyes	
c	Donkey, Addax, Orcas gazelle	Western Lowland Orillia	Gazelle, Ass, Oryx
d	Swayne's Hartebeest Roan Antelope Beetle	Porcupine, Mona Monkey Bush pig, Addax, Talapoin, Guenok, Zebra, Gorilla's teeth	Sunni, Leechwe, Wildebeest, Giraffe

Table 2. A sample of the responses of 3x 3 groups of 8-year-old primary pupils to the colour matching activity: a) pink; b) red; c) beige; d) brown

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.

However, we have 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.

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.

12. Conclusion

Physical science principles are implicit in watching 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. 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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