VISUAL IMPACT OF WILDLIFE DIORAMAS ON PRIMARY SCHOOL CHILDREN AS EXPRESSED IN DRAWING AND CONVERSATION

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KEYWORDS: CONSTRUCTIVISM, INFORMAL LEARNING, OUT-OF-SCHOOL SETTINGS, WILDLIFE, DIORAMAS, DRAWINGS, CONVERSATION.

ABSTRACT:

This study analysed the drawings of animals and plants made by 7 to 8 year old (Year 4) children immediately before and after a visit to the dioramas at the Natural History Museum, Mdina, Malta. The objective of the study was to gain insight into children's understandings of animals and plants, habitats and human constructed artifacts through observations of new dioramas of Maltese habitats at the museum. The theoretical framework draws on informal learning, constructivism and previous research on children's understanding of the natural world. A methodology was developed to interpret the children's drawings and to assess the differences between what they thought they would see and what they remember following the museum visit. The majority of the pre-visit drawing from the children showed expressed models of basic isolated animal outlines familiar to children in urban environments, with an almost complete lack of plant live. Drawings were flat with no perspective and context. The post-visit drawings were much richer in detail, number of items included and had a context indicating that children had accommodated some observations into their mental models. The drawings were analysed using a systemic network used to provide categorical data, with the ordinate categories of the network emerging from the drawings.

INTRODUCTION

This is a small scale research project that originates from my interest in science education at primary school level and particularly in the manner that children understand the natural environment through their direct experience of plants and animals. This study provides insights into children's learning in such places as museums, observatories and nature reserves and to show that such activities need to occur on a regular basis (Carrier Martin 2003).

The main focus of the study is dioramas that are a particular museum setting in which preserved animals and plants are exhibited in a representation of their natural habitat. Our time of increasing interest in conservation and biodiversity calls for an expansion of natural history dioramas. Dioramas, unfashionable in the UK but valued in the US, are currently attracting fresh interest as exemplified by recently opened dioramas in the Beginnings Gallery at the Museum of Scotland, Edinburgh and new dioramas at the Natural History Museum in Malta due for completion this year.

The declining populations of wildlife and increasing urbanisation are reducing the opportunities for children's direct experience of wildlife outside school, raising worries that the next, largely urbanised generation will have scarce knowledge and interest in wildlife (Huxham et al, 2006). This is particularly relevant to Malta, which possesses sparse endemic wildlife and over a third of its surface area is occupied by building. In this scenario, dioramas become particularly valuable to the urban community in constructing understanding of the different habitats and interactions between organisms (Tunnicliffe, 2005).

THEORETICAL FRAMEWORK

Constructivism is a theory of learning based on learners constructing rather than absorbing new ideas, and developing or modifying existing ideas (Bell, 1993). This is done mainly through the reinterpretation of snippets of knowledge partly gained by experiences and partly by communication with others (Selly, 1999). Conceptual change occurs during learning when learners develop useful cognitive skills which are used to construct meaning from existing ideas (Bell, 1993). Catherine T. Fosnot (2005, p.276) states:

> *'Most contemporary neurobiologists and cognitive scientists agree: Knowledge is actively constructed. The implications of constructivism for education, however, remain controversial'.*

In recent history, the science education community has seen a shift from positivism to constructivism, which is the contemporary paradigm shared by most science educators (Tomkins et al, 2001). At the core of the educational process are the way learners are aided to construct meaning from new information and the way the learner conducts dialogue with the self (Tunnicliffe, 2002). Empirical work shows that students with constructivist-oriented SEVs (Scientific Epistemological Views) tended to show better science learning outcomes than those with empiricist-aligned SEVs (Tsai & Lui, 2005). This strengthens the current believe that subject matter should be learnt through learner constructed knowledge rather than passive reception.

Children's learning about animals may be investigated by examining the mental models revealed through their talk and drawing when they come face to face with live or preserved animals. The mental model is the person's personal knowledge of the phenomenon. This knowledge will in certain aspects bear similarities and in others differences to scientifically accepted knowledge, which in the case of this paper is the appearance of the animal and its ecological habitat (Reiss & Tunnicliffe, 1999). Children are mostly stuck by anatomical features while viewing animals. These features may be revealed from the child's representations of the authentic specimens as constructed through the interrelation between the real object, mental model and the representation (figure 1) (ibid).

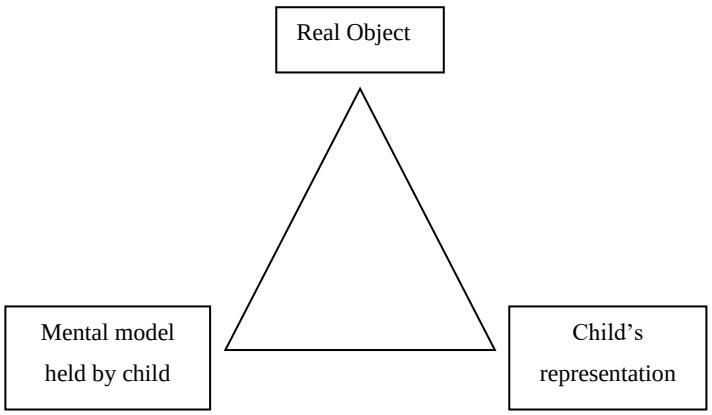


Figure 1. (adapted from Reiss & Tunnicliffe 1999, pg 143).

The representations may be written descriptions, verbal descriptions, drawings or three-dimensional models. In this context, observation emerges as an essential skill for scientific learning, which is here understood to mean active looking in search of understanding (Tomkins & Tunnicliffe, 2006). Tomkins and Tunnicliffe are particularly concerned that

present day science education is lacking observation skills in biological sciences and stress the importance of the skill as follows:

> *'Children's observations attached to a search for underlying meaning develops their understanding in a topic, particularly in biological ones, and will encourage pupils to develop better science inquiry skills if they are allowed more time to look and ponder'(2006, p. 8).*

Most of the methods employed for gathering information on pupils' understanding of scientific phenomena rely mainly on speech and writing. Very few empirical studies have made use and evaluated the potential of drawings in elucidating scientific understanding. This is not to state that drawing is necessarily superior to other means, but it does have advantages. One is the relative ease of obtaining a rich mass of data that related to the children's mental models. Another is the international suitability of drawing that transcends the huge diversity of languages (Reiss et al, 2002). Drawings may be as rich a source of evidence as language and open a window on children's thinking in all curricular areas. It may also serve as an alternative to verbal expression for children that are often able, through drawing, to show things that they cannot put into words (Lewis & Green in Bowker, 2007). However, finished drawings can not portray the thinking, talking, social interaction and mark-making sequences that form a fundamental part of the process (Coates & Coates, 2006: p.222). Drawings may also provide insights into children's cognitive, affective and social development (Bowker, 2007). Unfortunately, schools tend to suffocate children's natural inclination to use drawing as a mode of thinking and learning. Many teachers consider drawing a minor communicative tool, secondary to writing and speech (Anning, 1997).

METHODOLOGY

The quantitative analytical method used scores drawings using techniques based on the Personal Meaning Mapping (PMM) developed by Falk and Dierking (in Bowker, 2007). PMM is a constructivist method that recognises the visitor as an active participant in constructing understanding of an exhibit and also in that it considers learners having incomparable experience and knowledge. More so, PMM is a method that does not seek a 'correct answer' from children to demonstrate learning (Bowker & Jasper, 2007). The method allows for the transformation of qualitative data into numerical codes that can be statistically analyzed.

Research Design

Two grade 4 classes (7-8 year olds) from two different schools, a state co-educational school (school A) and an independent Roman Catholic school for boys (school B), were chosen. In both cases, the pupils are mixed ability and coming from the various social strata.

This research consisted of a three task process, pre-visit measure, the intervention (visit at the Natural History Museum dioramas) and post-visit measure. Data collected during the pre- and post-visit measures consisted of drawings and recorded conversations during the intervention (school visit). No control group was deemed necessary since the objective was to measure the effect, in terms of wildlife presented in them, of the dioramas on the children that had never seen them before. The post visit drawings were required to elicit enrichment in wildlife awareness following the observation of the dioramas. Interviewing the children about their drawing would have aided my understanding of the pictures produced. Diverse methodologies might disclose different perceptions and data collection methods can influence the type of perceptions identified (Bowker, 2004: p.232).

Pre Visit

A good understanding of children's interaction with exhibits reduces time wasting on inapt methods (Lateveer-de Beer, 2002). Schools have been criticised for allowing visits lacking sufficient preparation, focus and review (Osborne et al, 1997). Children need to be acquainted with the researcher. Morrow and Richards (1996: p.101) expressed the point as follows:

> *'Children are not used to being asked their opinions and to relate their experiences to unknown adults, and probably need to have some familiarity with the researcher'.*

I introduced myself as a teacher and researcher and talked to the children about wildlife for a few minutes so that they could familiarise themselves with me before the visit. I explained what we would be doing and that we were going to visit the Natural History Museum that week. The pupils were asked to draw what they thought they would be seeing and were given ample time to do so. I stayed for the whole duration of the task which lasted 30 minutes. Pupils were allowed to talk to each other and to include any comments or labelling to explain their drawings. I interfered as little as possible, only dealing with any questions raised by the children. Children possess great capabilities in communicating through drawing that enable them to overcome language barriers (Mavers, 2003).

During Visit

At the Natural History Museum, I planned and carried out the following activities:

1. A short briefing immediately prior to viewing the dioramas.
2. The teachers introduced the children into the diorama area in small groups of 2 or 3 pupils at a time. The spatial limitations necessitated such small manageable groups to allow observation and enable adequate capture of conversations.
3. I audio recorded conservations using an MP4 device (inconspicuous and easy to carry), took notes were necessary and asking questions to aid the conversational flow and clarify points. I was careful not to intervene or lead the children unduly not to influence their thoughts and so diminish the validity of the data collected.

Post-Visit

Pre-treatment, post treatment single group designs are widely used, but are vulnerable to a number of threats mainly associated with events, apart from the treatment, that occurs in the time between pre- and post-field activities. After the visit, I again asked the children to produce a drawing which school A did in class on the visit day, while school B did the following day. I followed the same procedure for the pre-visit task, but now asked the children to draw what they had actually seen at the dioramas. Pupils used HB pencil, pencil colours and plane A4 sheet paper in each case. I asked them to write their name, age and school on the back of the drawing. These were collected and analysed in relation to the ones drawn prior to the visit.

ANALYSIS

The 45 pupils involved in the study produced a total of 90 drawings, one pre- and one post-visit per pupil. Drawings were analysed qualitatively for biological content and also quantitatively through a scoring system developed for this study. The scoring system was based on the techniques used in the Personal Meaning Mapping (PMM) methodology employed by Falk & Dierking (cited in Bowker, 2007: 82).

The drawings were analysed on the following themes:

a) Animal diversity: reflects the number of different types of species of animals represented in the drawings.
b) Plant diversity: reflects the number of different types of species of trees and plants

represented in the drawings.

c) Artefacts and physical features: reflects human constructed structures and the abiotic (non-living) aspects of the environment found in the dioramas.
d) Diorama features: reflects environmental and ecological representations that evidence one or more of the dioramas viewed by the children.
e) Non-diorama features: reflects biotic and abiotic items not found in any of the dioramas viewed.

The scoring method took into account the:

i) Occurrence: presence of the themes in the drawing.
ii) Variety: the quantity of different kinds of appropriate images for each theme included in a drawing. For example, in diversity, each type of species was counted as one point.
iii) Elaboration: the quality of the overall shape of the items drawn, such as detail of leaves, trunk and flowers, in plants or wings, legs and body plan in animals. The overall quality of the drawing was also assessed in terms of the different themes included, link between items in the drawing and evidence of diorama representation (table 1.).

Table 1: scale used for scoring elaboration

Score	**1**	**2**	**3**	**4**	**5**
Animals – accuracy of overall form and distinguishing features	very poor	poor	average	good	excellent
Plants – accuracy of general form, shape of leaves, trunk, colour, texture, etc	very poor	poor	average	good	excellent
Overall: general quality of the drawing	very poor	poor	average	good	excellent

(Bowker, 2007: 85)

RESULTS

Qualitative considerations: pre-visit drawings

The children from School A drew mainly isolated animals of relatively large size. Most recognisable were birds, rabbit, butterfly, snails, rats hedgehog and bats, while the best drawn were the birds, snails, and butterflies. Other recognisable animals were snakes and insects, with some pupils writing names next to some of the animals. Quite a few drew vampire-like bats. A third (6/19) of the drawings shows evidence of environmental context, but ecological

relationships were barely evident in any of the drawings. Most pupils included a bird and snail (84%), rabbit and bat (58%) and a butterfly and hedgehog (53%).

Trees and flowers were the only evident plants noted. Human artefacts and physical features were rather sparse with 58% of pupils not including any such items at all. Main recognisable features were door, window, rubble wall, rocks, soil, clouds and the sun.

The children for School B also drew isolated animals with only 15% of drawings containing more than four animals. Most recognisable were birds, rabbits, butterflies, snails, starfish, crabs and bats, with the best drawings being those of birds, snails and bats. Recognisable others were snakes, crocodile, cat, cow pig and eagle, with 20% of pupils writing names near the animals drawn. A fifth (5/26) of drawings show environmental context, but no ecological relationships were evident. Most frequently noted animals were birds (73%), snails (31%) and others not found in the dioramas (65%). A tree was included in 5 out of 26 drawings while a flower was included only once. Very few human artefacts and physical feature were drawn; in 85% of cases none were noted.

Post-visit drawings

The school A pupils produced richer drawings of better quality with more recognisable animals and wider variety. Most drew a bird (84%), a butterfly and (53%) a cock and snail (47%) and different birds (42%). Other animals drawn were shells, rabbits, rats, starfish, bats, spiders and hedgehog.

More trees (53%) and flowers (42%) were included with almost all (90%) drawings showing environmental context from one or more dioramas. Most drawings (84%) had a clear diorama setting seen at the museum mainly; 58% yard, 47% beach, 32% field and 26% valley. Main diorama physical features and artefacts were a door, window, boat, sand, rocks and soil. Non-diorama items found were other animals, clouds and sun.

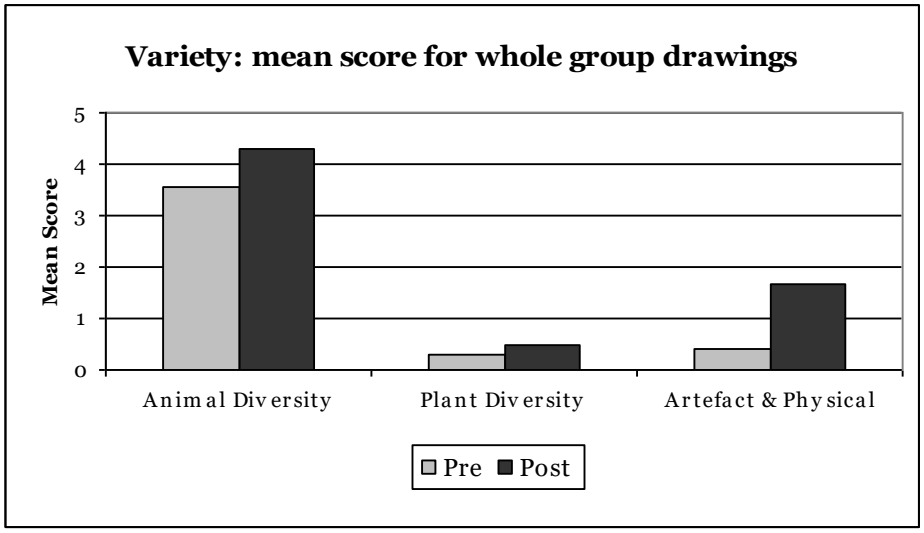
The school B pupils used colour in their post-visit drawings, thus making them much richer in quality. Again, better recognisable animals and more variety was noted. Pupils drew mainly a bird (73%), rabbit and bat (27%), and snails and starfish (23%). Relatively few (20%) drawings had environmental context from dioramas, while only 20% had a clear diorama setting. Very few trees and flowers were noted too. Dioramas seen were mainly beach, field and valley, with rubble wall, boat, sand, rocks, water and soil being the physical and artefact

features noted. Non-diorama items seen were other animals, sun and unusual things like guns and syringes.

QUNATITATIVE CONSIDERATIONS

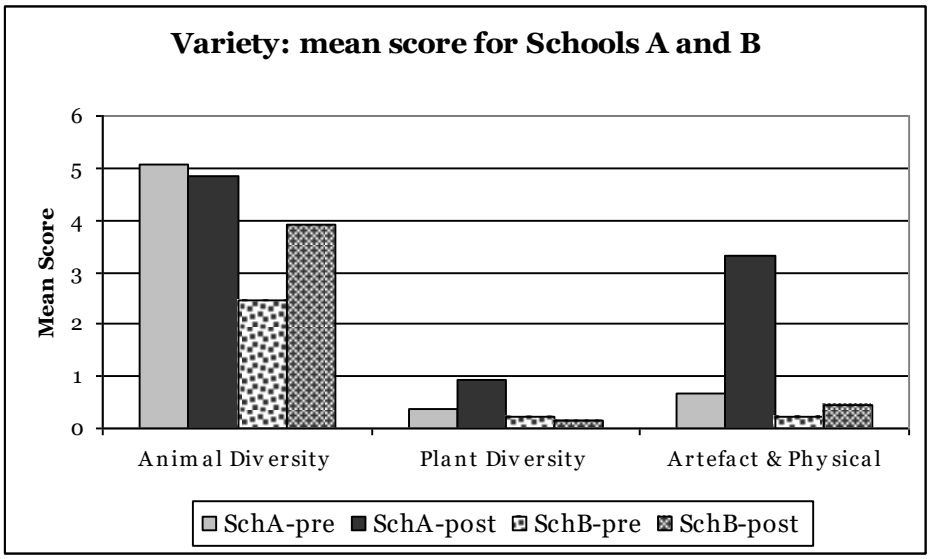
Variety scores

Mean scores for animal diversity do not show a significant increase in variety in post-visit drawings ($t=1.69$, >0.05) mainly due to a decrease in the score for School A pupils. There was a significant increase however, for school B ($t=2.92$, <0.05). School A pupils showed significantly more variety in pre-visit drawings compared to School B ($t=6.09$, <0.05). However, there was no significant difference between schools in the post-visit drawings ($t=1.22$, >0.05).

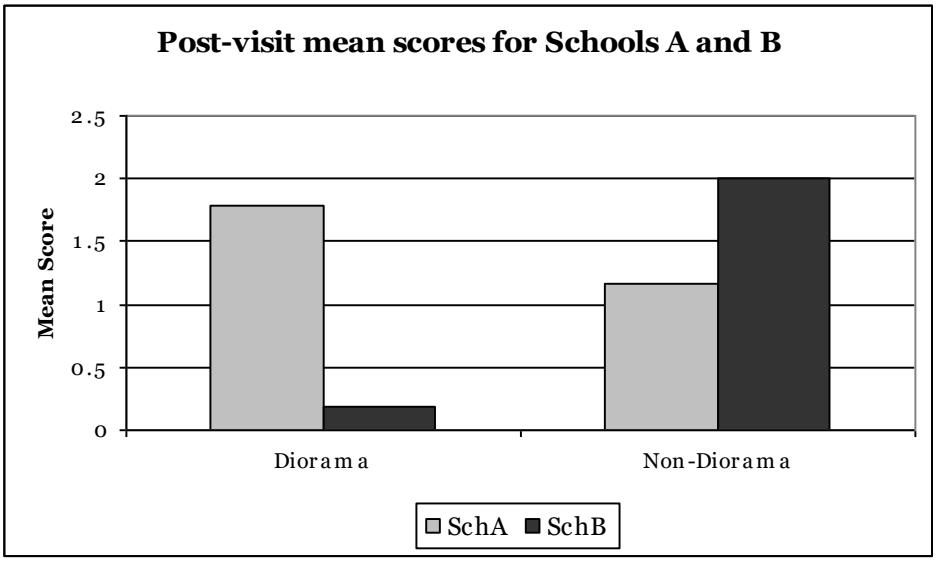


There was a significant increase in the artefacts and physical features in the post-visit drawings ($t=4.40$, <0.05) as a whole group, largely due to a high score[1] obtained by School A pupils. More so, there was a significant difference between the post-visit scores of both schools ($t=6.99$, <0.05).

[1] This score seems abnormally high, but is due to most of the School A pupils drawing no or just one artefact item in pre-visit while including 3 or 4 in post-visit drawings. Pupils seemed to have greater awareness of the physical component of habitats after observation of the dioramas.

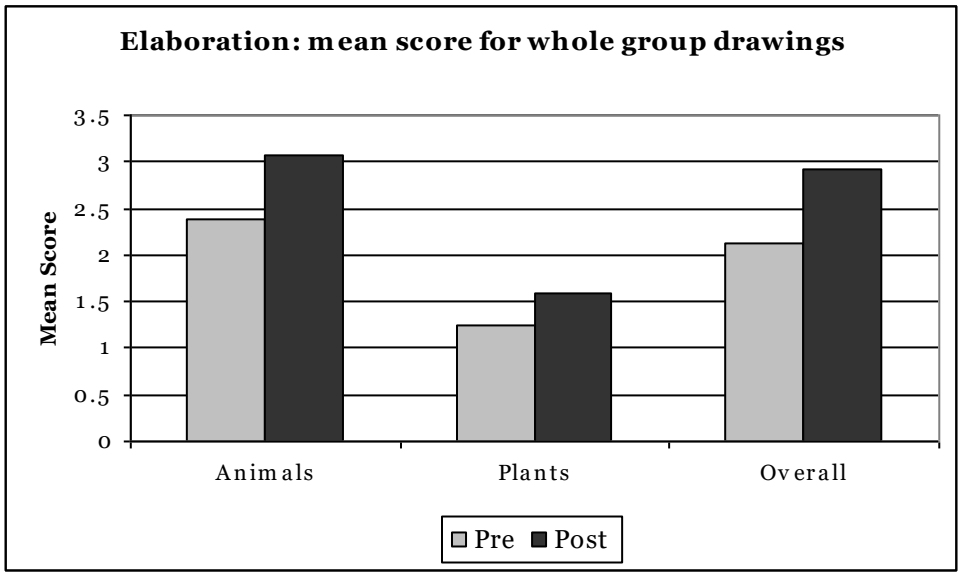


There was a significant difference between the two schools' mean scores for the diorama (t=5.85, <0.05) and non-diorama features (t=2.21, <0.05) in the post-visit drawings. School A pupils' drawings had more diorama settings than those of school B, while the reverse applies for the non-diorama features. The pre-visit drawings did not show diorama setting features since the pupils had never seen them before.

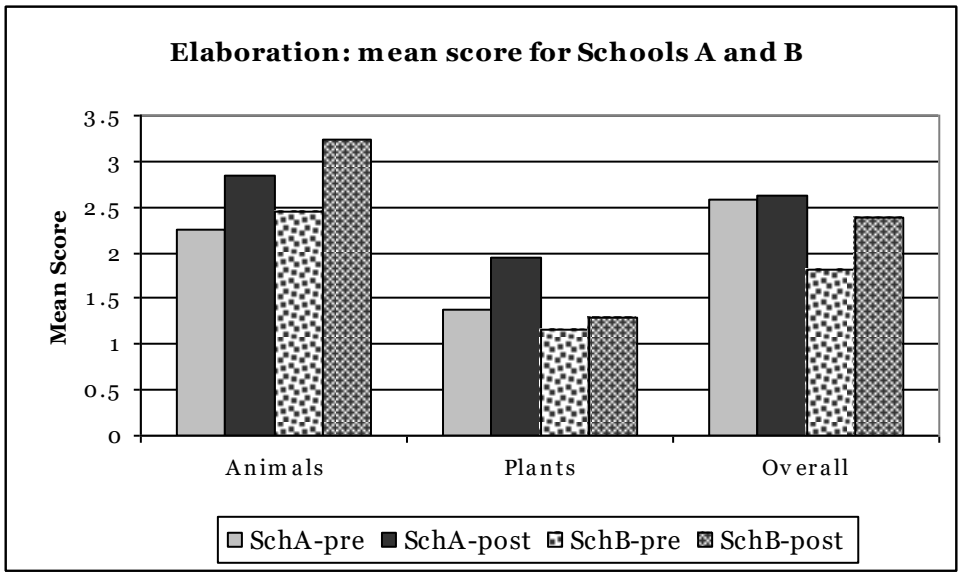


Elaboration Scores

This refers to the overall quality of the drawings in terms of animals, plants and diorama features. There was a significant increase in scores from pre to post-visit drawings for the whole group. The increase was observed in the animal (t=5.63, <0.05), plant (t=2.71, <0.05) and overall categories (t=3.78, <0.05).



Both schools A and B showed a significant increase in their post-visit scores for animals. School A had a significant increase in both the plants and overall scores but school B did not show any significant increase in either of these two categories.



DISCUSSION

In this study I focused on drawings and conversations as the primary data. Children were not probed to discover further knowledge and to add this to their drawings or to label items in the drawings. They were only instructed to draw what they thought they would see in terms of animals and plants, and then to draw what they had actually seen.

The content of the pre-visit drawing are an illustration of the children's prior knowledge that they acquired from school and other resources. Pupils of both schools drew, in most cases

less than four, isolated and unconnected animals. Results also seem to confirm that children's aesthetic longing for nature is connected with the more prominent animals such as mammals and the birds (Kellert, 1996). The fact that few pupils use knowledge relating to habitats where animals naturally occur probably is a result of the predominance in science teaching on naming and categorizing organisms as isolated entities. Research has also shown that few pupils show an adequate integration of understanding of environments (Tunnicliffe & Reiss, 1999:146). Very few pupils included any form of plant life strengthening the view that plants are of no immediate importance to children (Bowker, 2007:91 & Johnson, 2004:79). The majority of children drew birds and animals including snails, rabbits, bats, butterflies and hedgehogs which were also the best drawn.

In their post-visit drawings, pupils showed some level of learning. Pupils produced better drawings, richer in quality and also in colour. There was no significant increase in animal variety, i.e. number of difference animals drawn. School B demonstrated a higher level of learning than school A, whose pupils came to the visit with better knowledge. Again, the pupils were less affected by the flora in the exhibits, which really did not contain much plant life. Nonetheless, more trees and flowers were noted in the post visit drawings, meaning that the flora had an effect, although not very significant, on the pupils. A marked difference was noted in the ecological relationships. Animals in post-visit drawings were incorporated into an environmental context as seen in the dioramas. This was more the case for school A than school B with only 20% of pupils of the latter showing any environmental context. This could have occurred since the School A pupils drew their second drawing on the day of the visiting while those is School B drew then the following day.

Pupils mostly drew the house yard, beach and field, i.e. the environments that they were mostly familiar with. Most interesting aspect was how pupils placed animals in an ecological setting and not as isolated objects. A significant increase in physical features is evidence of more environmental context in post-drawings. The School A pupils seem to have noted this more and incorporated it into their mental mode, better that School B did and falls in line with the Ausubelian maxim that the single most important factor influencing learning is what the learner already knows (Bell, 1993: 6).

This study gives an indication that, when allowed, children can reveal what they know and assimilate in their mental model through drawings (Bowker, 2007:94). One may see this from changes in terms of number of different plants and animals, better quality and richness, and

more environmental features drawn. Nonetheless, drawing is perhaps not an ideal tool for capturing all that children notice in museum exhibits. Conversations recorded show that children observed a wider variety of animals than they actually drew and mentioned animals that they did not include in their drawings.

CONCLUSION

The museum experience lasted for a relatively short time and limited space available at the museum to leave any substantial impact on the children's learning. The museum lacks an organised and property designed educational programme, and the present dioramas are not designed and built with any such propose in mind. Some form of well-focused, enjoyable and engaging workshops conducted by trained staff would surely help to make the experience more educationally enriching. What we see, hear, taste, touch, smell and do gives us six main 'pathways to learning' (DfES, 2006). Therefore, museum exhibits should incorporate all these senses.

I could note that most children enjoyed the drawing activity and particularly the museum experience. Drawing on site would have been more appropriate but the museum is not educationally friendly in this respect. The time spent viewing the dioramas needs to be longer, while it was not always possible to capture all that the children were saying. Talking to the children about their drawing would be helpful in better understanding their representations. Drawings should also be analysed by other competent people, something that was not possible here.

Scoring of drawings provides semi-quantifiable data that help in interpreting and analysing of children's learning (Bowker, 2007: 94). It is not right to reduce the complex and rich data found in drawings to numbers, while it would be equally unwise to draw too many conclusions from a relatively short learning experience. However, quantifiable data can be useful in strengthening the analysts' interpretations and conclusions about drawings and also revealing more about children's learning experiences. Results show that viewing of natural settings does affect the children's perceptions and that these are, at least partly, incorporated in their mental models. Different children evidence this to a varying degree within their drawings. Triangulation with other forms of data would probably reveal more.

BIBLIOGRAPHY

Alderson, P. and Morrow, V. (2004). Ethics, Social Research and Consulting with Children and Young People. (2 ed.). Essex: Barnarbo's.

Anning, A. (1997). 'Drawing Out Ideas: Graphicacy and Young Children'. International Journal of Technology and Design Education, 7 (3), 219-39.

Bell, B. F. (1993). 'A constructivist view of learning in', Chilren's Science, Constructivism and Learning in Science (pp. 23-29). Waikato: Deakin University.

Boulter, C., Reiss, M. J. and Tunnicliffe, S. D. (2007). 'Seeing the natural world: a tension between pupils' diverse conceptions as revealed by their visual representations and monolithic science lessons '. Visual Communication, 6 (1), 99-114.

Bowker, R(2004) 'Children's perceptions of plants following their visit to the Eden Project'. Research in Science & Technological Education, 22(2), 227 – 243.

Bowker, R. (2007). 'Children's perceptions and learning about tropical rainforests: an analysis of their drawings '. Environmental Education Research, 13 (1), 75-96.

Bowker, R. and Jasper, A. (2007). ''Don't forget your leech socks'! Children's learning during an Eden Education Officer's workshop '. Research in Science & Technological Education, 25 (1), 135-150.

Braund, M. & Reiss, M. (2006) 'Towards a More Authentic Science Curriculum: The contribution of out-of-school learning'. International Journal of Science Education, 28(12), 1373 – 1388.

Carrier Martin, S. (2003). 'The Influence of Outdoor Schoolyard Experiences on Students' Environmental Knowledge, Attitudes, Behaviors and Comfort Levels'. Journal of Elementary Science Education, 15 (2), 51-63.

Coates, E. & Coates, A. (2006), 'Young children talking and drawing'. International Journal of Early Years Education, 14(3), 221 – 241

DfES (2006), Learning Outside The Classroom Manifesto. DfES Publications, Nottingham.

Dierking, L. D., Burtnyk, K., Chner, K. and Falk, J. H. (2002), Visitor Learning in Zoos and Aquariums-a literature review. Annapolis, MD: American Zoo and Aquarium Association.

Fosnot, C. T. (2005). 'Constructivism Revisited: Implications and Reflections, ' in C. T. Fosnot (ed.), Constructivism: Theory, Perspectives and Practice (2 ed., pp. 277-290). London: Teachers College Press.

Gorard, S. (2002). How do we overcome the methodogical schism (or can there be a 'compleat' researcher)? : TLRP Reseach Capacity Building Network Occasional Paper 47. Cardiff University School of Social Sciences.

Huxham, M., Welsh, A., Berry, A. and Templeton, S. (2006). 'Factors influencing primary school children's knowledge of wildlife.' Journal of Biological Education, 41 (1), 9-12.

Johnson, S. (2004). 'Learning science in a botamic garden ', in M. Braund and M. Reiss (eds), Learning Science Outside the Classroom (pp. 75-93). London: Routledge Falmer.

Kellert, S. (1996). The Value of Life, Biological diversity and human society. Washington, D.C.:Island Press.

Laterveer-de Beer, M. and Tunnicliffe, S. D. (2002). 'An Interactive Exhibition about Animal Skeletons: Did the Visitors Learn Any Zoology?' Journal of Biological Education, 36 (3), 130-34.

Lindsay, G. (2000). 'Ethical Issues', in A. Lewis and G. Lindsay (eds), Researching children's prespectives. Buckingham: Open University Press.

Mavers, D. (2003). 'Communicating meanings through image composition, spatial arragement and links in priamry school student mind maps.' in C. Jewitt and G. Kress (eds), Multimodal Literacy (pp. 19-33). York: Peter Lang.

Maxwell, J. A. (1992). 'Understanding and validity in qualitative research.' Harvard Educational Review., 62, 279-300.

Morrow, V. and Richards, M. (1996). 'The ethics of social research with children: an overview.' Children and Society, 10 (2), 90-105.

Osborne, J., Lucas, A. M. and Tunnicliffe, S. D. (1997). 'School visits to zoos and museums: a missed educational opportunity?' International Journal of Science Education, 19 (9), 1039-1056.

Reiss, M. and Tunnicliffe, S. D. (2001). 'Students' Understandings of Human Organs and Organ Systems'. Research in Science Education, 31, 383-399.

Reiss, M. J. and Tunnicliffe, S. D. (1999). 'Building a Model of the Environment: How Do Children See Plants?' Journal of Biological Education, 33 (3), 142-148.

Reiss, M. J. and Tunnicliffe, S. D. (1999). 'Conceptual Development'. Journal of Biological Education, 34 (1).

Reiss, M. J., Tunnicliffe, S. D., Andersen, A. M., Bartoszeck, A., Carvalho, G. S., Chen, S.-Y., Jarman, R., Jonsson, S., Manokore, V., Marchenko, N., Mulemwa, J., Novikova, T., Otuka, J., Teppa, S. and Van Rooy, W. (2002). 'An International Study of Young Peoples' Drawings of What Is Inside Themselves'. Journal of Biological Education, 36 (2), 58-64.

Robson, C. (2002). Real World Research: A resource for social scientists and practitioner-researchers. (2 ed.). Oxford: Blackwell.

Scott, D. (1996). 'Methods and data in educational research.' in R. Usher and D. Scott (eds), Understanding Educational Research. (pp. 52-73). London: Routledge.

Selley, N. (1999). 'Constructivit Learing in', The Art of Constructivist Teaching in the Primary School (pp. 3-6). London: David Fulton Publishers.

Teddie, C. and Tashakkori, A. (2003). 'Major issues and and controveries in the use of mixed methods in the social and behavioural sciences.' in C. Teddie and A. Tashakkori (eds), Handbook of Mixed Methods in Social and Behavioural Research. (pp. 3-51). Thousand Oaks, CA: Sage.

Tomkins, S. P. and Tunnicliffe, S. D. (2001). 'Looking for Ideas: Observation, Interpretation and Hypothesis-Making by 12-Year-Old Pupils Undertaking Science Investigations'. International Journal of Science Education, 23 (8), 791-813.

Tomkins, S. P. and Tunnicliffe, S. D. (2006). 'Bring back the Nature Table!' Environmental Education, 82, 8-11.

Tsai, C. C. and Liu, S. Y. (2005). 'Developing a multi-dimensional instrument for assessing students epistemological views toward science'. International Journal of Science Education, 27 (13), 1621-1638.

Tunnicliffe, S. D. (1996). 'Conversations within primary school parties visiting animal specimens in a museum and zoo.' Journal of Biological Education, 30 (2), 130-141.

Tunnicliffe, S. D. (1999, August 8-10), Science out of school classroom. Paper presented at the 23rd Annual Meeting of JSSE & JSSE-ICASE-PME International Joint Conference. .

Tunnicliffe, S. D. (1999). 'Stages of a zoo visit'. International Zoo News, 46 (6), 343-346.

Tunnicliffe, S. D. (2002). 'The educational value of natural history collections in learing about biodiversity. ' The Biology Curator, (22), 27-40.

Tunnicliffe, S. D. (2005). 'What do Dioramas Tell Visitors? A Study of the history of Wildlife Diorama at the Museum Of Scotland Current. ' Trends in Audience Research and Evaluation., 18, 23-31.