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# Conversations of Family and Primary School Groups at Robotic Dinosaurs in a Museum? What Do They Talk About?

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## Abstract

*The story from the museum may not be read by visitors, who come with their own knowledge and understanding and read a different story in the animals. The visitors read a story which makes sense to them and builds on what they already know and interests them.*

*Increasingly, robotics models are being used in natural history museums, science centers, and zoos to attract visitors and tell some kind of story. What do the visitors actually talk about when looking at such robotic animals? The visitors reported on in this paper were primary school groups and families. Do they talk about similar things at the same exhibits, even though the schools visit for educational purposes and the families of their free choice in their leisure time? Furthermore, within school groups, do different subgroups respond in a different way, gauged by the content of their conversations, to similar robotics? This paper studies the conversational content of primary school and family groups at two different robotics dinosaur exhibits in the Natural History Museum, London. One of the exhibits is no longer on display. These verbal responses were analyzed through using a systemic network. Results indicate that visitors commented on a very simple story told through the design of the exhibit and the movements of the specimens. Visitors also noticed the salient features of the animatronics models as reptiles.*

## Introduction

The Children's Museum in Indianapolis, Indiana, has changed its IMAX cinema into DINOSPHERE, with animatronics as well as biofacts from dinosaurs, intersecting hands-on exhibits, and a chance to see scientists working on dinosaur remains. This, like many other dinosaur exhibitions, is a prime target for field trips. Museums work hard at providing facilities and information for students and teachers on such field trips. Knowing what museums or schools want to tell visitors is not enough, however. A previous study (Tunnicliffe, 1999) showed that the exhibit per se is insufficient to attract attention and meaningful observations and that the way the story is told is crucial to the visitor's experience. Moreover, children possess coherent models of the phenomena that are frequently presented in classroom settings. As Driver, Guesne, and Tiberghien (1985) point out, different children describing the same phenomenon give various and diverse interpretations. Children construct their own meanings in the classroom, and, thus, it follows that they will also do this in museums on field trips when looking at exhibits. Schoolchildren begin their visit with two agendas: (1) a child-centred one anticipating fun and visits to the gift shop, and (2) a school-oriented one expecting a new learning opportunity that utilizes the expertise of the collection (Birney, 1988). School visits to museums are undertaken for educational reasons (Marshdoyle, Bowman, & Mullins, 1982) and are, thus, part of the formal educational studies of elementary students (Tunnicliffe, 1998).

The observations made in museums are an important aspect of science education. Classifying, identifying, pattern seeking, and exploring are often seen as fundamental to a wider set of process skills needed by children doing science as their learning develops at the lower secondary level (Key Stage 3)[1] (Watson, Goldsworth, & Wood-Robinson, 1999). Children's careful observation is basic to the development of their science understanding and to the development of their scientific thinking. Klahr (2000) describes four processes in scientific thought as a whole: (1) Inquiry, (2) Analysis, (3) Inference, and (4) Argument. These processes build in a stepwise manner upon each other. *Inquiry* is the most basic of these and arises through observation and experience by a stimulated imagination and a developing sense of causality in the mind of the child. Moreover, the animate/inanimate distinction is known to be a fundamental concept that emerges early in infancy, and children infer much more from animals than from a range of inanimate artifacts (Gelman, 1988). This is marked in preschool children (Heyman & Gelman, 2000) and was, in their work, demonstrated clearly by their higher ranking of those objects with "animacy." This attractiveness of the animate world is exploited by animatronics and robotics, and it may encourage children to look more closely than they would at still animal models.

Some information about the understanding of visitors at animatronics may be obtained from directly questioning the visitors after they have viewed an exhibit. Such a technique can be useful, particularly if the visitors were not cued in before their observations that they would be questioned afterwards. Such responses are different from the spontaneous, instant utterances elicited by the exhibits. Furthermore, such spontaneous remarks are different from the responses made when visitors are taken around to exhibits by a guide, such as a curator or a docent, when conversations have a more focused conversational content about the exhibits viewed (Birney, 1988; Brown, 1997).

The comments of school groups in zoos and in a natural history museum are not uniform in composition nor in response. The content of responses to various types of animal exhibits vary according to the age of the students (Kellert, 1985; Tunnicliffe, 1997), whether an adult is present, and the gender of the students. Informal learning environments for science developed with gender equity in mind have the potential to encourage students of both genders to build connected science experiences (Ramey-Gassert, 1996). There exists a belief, however, that males are logical and that females are intuitive and orientate theist arguments and interest to the social context of a problem (Solomon, 1997); hence, the content of conversations at the animatronics would be expected to have different emphases.

School parties are subdivided into smaller groups accompanied by chaperones that are usually not teachers nor briefed on the educational objectives of the visit. Within these subgroups, the children divide themselves into subordinate groups of boys alone, girls alone, or mixed groups, with or without the chaperone participating in their small group (Tunnicliffe, 1997, 1998). Thus, differences between constituent subgroups need identifying so that effective educational strategies can be implemented and monitored. Furthermore, is a family visit to the same exhibits similar or different in conversational content during educational visits to the same animatronic dinosaurs? Conversations generated by these two groups—families and school groups—show that the conversations are similar in nature with the only statistical difference being more conversations having an affective component in the elementary school groups (Tunnicliffe, 1996a). It further explores whether there are statistically significant differences in the content of conversations within the constituent subgroups of the school parties: between age groups; single and mixed gender groups; and the groups with a teacher, with another adult, and groups of only students and no adult. It also explores whether the message of the exhibits reaches these audiences.

If the students, teachers, and chaperones *are* carrying out educational tasks and teachers *have briefed* effectively, both the other adults who accompany a school group and the students themselves—all subgroups of one overall school party—should have a similar conversational content while at the animal exhibits. Variation in the composition of the group, through gender or the status of adults running the group, may have an effect on the conversational content, however. School groups have educational objectives for their visit, which may include furthering students' understanding about biological science in line with the progress expected in the National Curriculum for England in the programs of study and the attainment targets for Key Stages 1 and 2 (Department for Education and Employment [DfEE], 1995). Thus, age of the groups would also be expected to influence the content, with greater content on certain areas, which reflect the curriculum focus expected at different ages.

Family groups embark on their visits with the expectation of a social event during which they may or may not notice some phenomena that may relate to concepts they already hold and prior experiences that they recall. Some of the visitors, such as school groups, may even be diligent and use the exhibits fully (Serrell, 1997).

## The Dinosaur Exhibits

Animatronics are becoming established as a useful exhibit form in museums, and dinosaurs are the animals most often shown in this exhibit form. The sequenced and predictable movements and the portrayal of extinct animals as moving entities render such exhibits "safe monsters" for young elementary children who, hitherto, were only able to view dinosaurs as static fleshless fossil skeletons or immobile reconstructed models.

How effective are animatronics in transmitting the message that the institution has for the visitors about the animals thus depicted? There were two separate animated dinosaur exhibits in the Natural History Museum in London. Each had a different specific message, as well as providing, inherently through their design, information about the believed anatomy and behavior of dinosaurs. One, the pavilion diorama, was a reconstruction of a scene as it is believed to have been at the time when the animals portrayed were alive. It contained four animated dinosaurs; the larger of these, *Terontosaurus*, was lying on the ground. It was being attacked by three smaller animals called *Deinonychus.* These animated models made movements in a regularly repeated sequence, and there was a regular, loud noise "off" as part of the animation cycle, which "made" the dinosaurs stop and look up as if distracted by the noise and then continue what they were doing, and continuous insect-type background sounds. Exhibits with no visual barriers heighten visitors' perceptions, and concrete exhibit types are more effective in attracting and holding visitors' attention (Peart, 1984). Thus, this exhibit was a bisensory experience because it could be seen and heard in terms of the sensory perceptions available to visitors (Dale, 1954). Moreover, the design of the pavilion dinosaur diorama enabled the visitor to look down at the scene over a waist high railing. Attached to the railing were two identical, short labels and, as such, had more to offer the visitor in terms of senses stimulated and information potentially conveyed. The visitors, however, as passive participants or voyeurs in a flashback scene—which they perceived through sight and sound—had no opportunity to interact with the exhibit in any other way than "talking" to it and being "minds-on."

The second animated dinosaur exhibit is still located at the exit of the main gallery and several floor-to-ceiling panels either side of the "pathway." Immediately before the model, the question, "Did dinosaurs look like living animals?" is posted. The model is approximately one meter in length, placed in a type of transparent tank with no setting or exhibit furniture. The model is programmed to make a sequence of movements in a regular cycle, stretching its back leg, moving its tail, opening its eye, and showing breathing movements. Many visitors thought it was real.

We, as science educators, are concerned with not only science learning in the formal curriculum but with the furtherance of civic science. We have to consider the extent to which viewing robotics animals assists visitors in further developing their concepts about the dinosaurs and whether the messages explicit within the exhibits reach the visitors. Listening to and analyzing the unsolicited conversations of visitors is one way to ascertain whether or not the visitors attend to the message of the exhibits and how they do interpret what they view. Such exhibits have several aims. First, to inform about the characteristics of dinosaurs, visitors can notice the salient features used in taxonomy and, indeed, the second exhibit of one model seeks to reinforce the reptilian features of dinosaurs. Second, the diorama clearly showed a predator-prey scenario. Last, the diorama was part of the story picked up later in the gallery of extinction where several theories are put forward and visitors are invited to draw their own conclusions. Extinction and conservation are of concern and are topics of civic science, which receive media attention.

## Method of Analyzing the Content of Visitor Conversations

Essentially, unsolicited conversations were tape-recorded and then analyzed according to the categories of a systemic network, which had been designed for this study. A systemic network is a type of analysis that changes qualitative data into quantifiable data, and each topic of conversation was coded according to the systemic network developed from the work of Bliss, Monk, and Ogborn (1983). A unit of conversation was defined as the group conversation in front of any one exhibit from the beginning of the conversation until it ceased. There were 74 categories in this network, which merged from reading and re-reading the transcripts and arranging them in a conceptual hierarchy of relationship. A bar, "[," indicates that an attribute may be either, but not a member of both, categories. A bracket, "{," indicates one of a number of categories which an animal may have. Hence, in the network used for analysis, a comment about something (e.g., a label was either made or not made) is indicated in the network by a bar. An exhibit-focused comment, however, may have a reference to say the label and the animal in the exhibit and, thus, is shown by bracket (Figure 1). The total number of conversations collected was 598. A conversation was judged to be the exchanges at an exhibit by the group being observed from the time they started to speak to when they stopped.

The "animal as exhibits—focused" category was divided into six subordinate groups: (1) interpretative comments, which embrace knowledge source comments—a question or statement of fact; (2) affective comments, which included emotive responses, such as "Ah!" or "Ugh," as well as comments about other attitudes—human-animal interactions (and vice versa) and welfare comments; (3) environmental comments, referring to the natural habitat or endangered status of the species; (4) comments about the animals' structure; (5) comments about the animals' behaviors; and (6) comments about the animals' names.

**Figure 1. Other Categories Segment of Network—This Segment for Interpretative Comments**

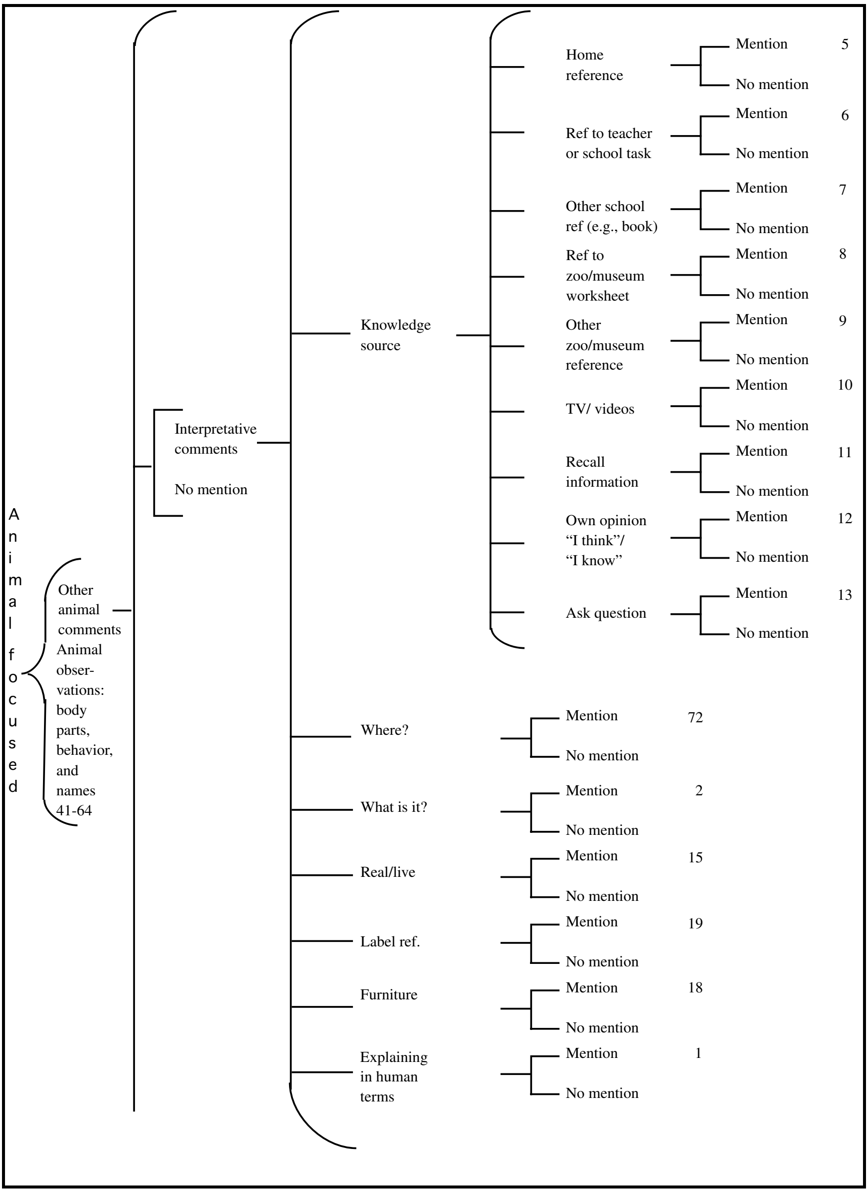


**Figure 2. Animal Observations**

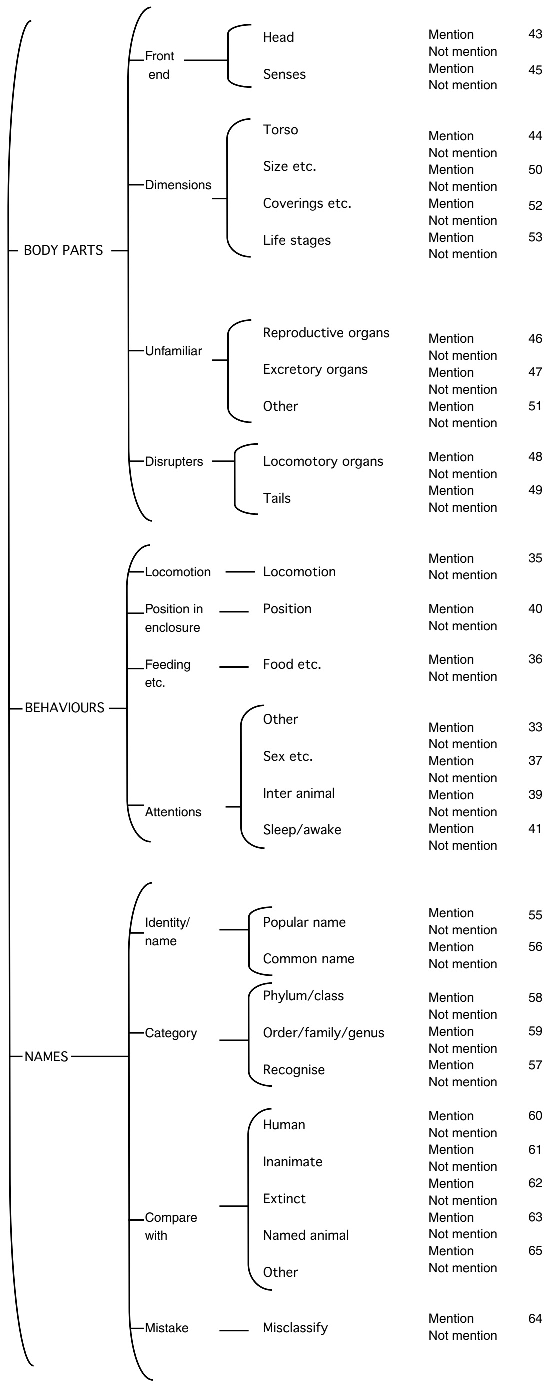


Figure 1 illustrates categories of the network for conversational content, and Figure 2 shows the fine-grained coding for animal observations commented upon by the groups. After initial reading analysis, it was apparent that the comments in each superordinate category—body parts, behavior, and naming—were grouped within four superordinate categories—the body part being the front end of the animal; the dimensions (e.g., size, color, etc.); features which were unfamiliar to the viewers and included structures such as claws; and disrupters (i.e., legs and tails of animals which disrupt the outline of the animals' shapes) (Tunnicliffe, 1995).

Each conversation unit was categorized with the appropriate number from the networks such as the following:

*Girl: Look/it's/moving. /That's/a* Tyrannosaurus.
*Adult: No, it's not/. It's* Tectonosaurus.

That typical exchange was coded using the numbers of the category topic as follows:

71 /21/ 35 / 21/24/ 56 /64
*Girl: Look/it's/moving. /That's/a* Tyrannosaurus.
12 / 56
*Adult: No, it's not/. It's* Tectonosaurus.

This conversation was excerpted from one of the transcripts at the exhibits, showing the use of the coding system (see the relevant category number inserted above the word or phrase). For each conversation, these results were entered into a MiniTab® worksheet. Each conversation was numbered (e.g., 1, 2, and so forth), and a column represented each category of the network across the worksheet. Hence, using the above example, "21" and "12" would be entered only once in the worksheet and indicated as a "1" in the relevant column. Where a category was not mentioned, a "0" was entered into the columns. Once the worksheet was completed, Chi Square tests were carried out on the relevant columns to establish significance. There were also columns in the worksheet for demographics and other data, such as gender of the group and whether a teacher or another adult were present in the group, so that the conversational content of groups with or without an adult, of boys only, girls only, and mixed groups could be compared.

## Profile of the School Groups

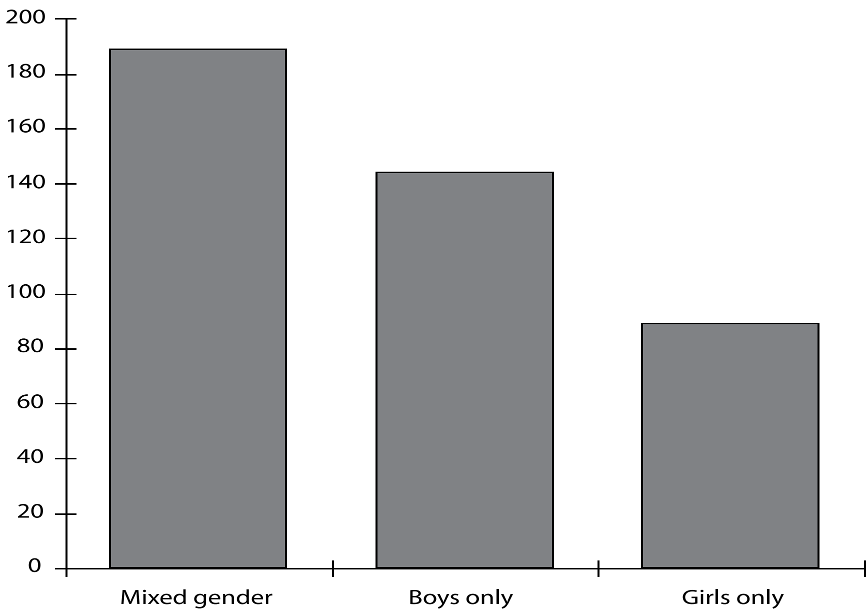
The schools with which the work was conducted were chosen because they were expected at the museum on the days when research was scheduled and they agreed to be part of the study. A total of 598 conversations were collected and analyzed. Of these, 176 were from families, and 422 were of the school groups whose ages and the respective numbers are shown in Table 1. Museum staff did not accompany the groups, hence they were self-guided. Some groups were accompanied by a teacher, some by a chaperone from the school such as a parent, and some were students alone. The data are of conversational units generated by the group, which contained an adult as well as the children. The various topics of conversational content were only counted once.

**Table 1. The Age of School Groups Talking About the Dinosaurs**

| Age of Group | Number of Conversations $n$ = 422 |
|---|---|
| Preschool and 5-year-olds | 49 |
| 6- and 7-year-olds | 222 |
| **Total Age of Group 1** | **271** |
| 8- and 9-year-olds | 115 |
| 10- and 11-year-olds | 27 |
| 12-year-olds | 9 |
| **Total Age of Group 2** | **151** |

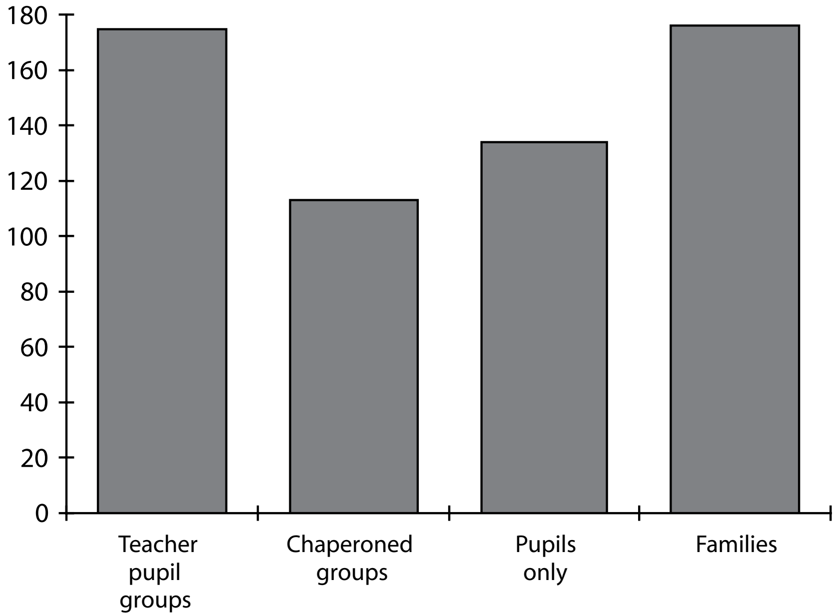
Figure 3 shows the distribution of the conversations of school groups according to the gender of the group members.

**Figure 3. Distribution of the Number of Conversations of School Groups According to Gender of the Group Members (Total Number of Conversations: 422)**




The number of boys only conversations was 144, while the number of girls only conversations was 89. The number of mixed gender group exchanges was 189. Figure 4 shows the number of conversations collected according to the social organization with the school groups.

**Figure 4. Numbers of Conversational Exchanges Generated at Museum Animal Exhibits by Primary School Groups (*n* = 422) and Their Subgroups and Family Groups**




## Results

The main topics of the conversations that were generated are shown in Table 2. The significant differences between all school groups and family groups are that there were significantly more management/social comments from the families and significantly higher content of comments among school groups referring to anatomical features and behavior as well as more knowledge source comments, questions, and statements of knowledge (e.g., "I know that is a dinosaur" and "Is that a *Tyrannosaurus rex*?").

**Table 2. Comparison of Content of Conversations at Robotic Models of School Groups with Family Groups (Main Categories)**

| Category | School Groups ($n$ = 422) $f$ | % | Family Groups ($n$ = 176) $f$ | % | $\chi^2$ (1 df) | Probability | Phi[2] |
|---|---|---|---|---|---|---|---|
| Management/ Social | 304 | 72 | 147 | 84 | 8.84 | $p < 0.005$ | 0.02 |
| Exhibit access | 239 | 57 | 91 | 52 | 1.22 | | |
| Other exhibit comments | 173 | 41 | 79 | 45 | 0.77 | | |
| Body parts | 309 | 73 | 96 | 55 | 19.82 | $p < 0.005$ | 0.03 |
| All behavior | 363 | 86 | 119 | 68 | 26.91 | $p < 0.005$ | 0.05 |
| Naming | 176 | 42 | 84 | 48 | 1.83 | | |
| Affective attitudes | 229 | 54 | 93 | 53 | 0.10 | | |
| Emotive | 199 | 47 | 83 | 47 | 0.002 | | |
| Interpretative | 400 | 95 | 136 | 77 | 40.99 | $p < 0.005$ | 0.07 |
| Real/alive | 170 | 40 | 63 | 36 | 1.05 | | |
| Knowledge source | 329 | 78 | 116 | 66 | 9.48 | $p < 0.005$ | 0.02 |
| Environment | 19 | 5 | 13 | 7 | N/A | | |

The data in Table 2 show that both groups—schools and families—shared a similar focus on emotional comments when looking at the animatronics, unlike the response of similar groups to live animals in zoos (Tunnicliffe, 1996a). Both groups named the animals (35% and 42%, respectively), with 20% of school groups categorizing the animals (e.g., plant eaters) and 26% of family groups doing so. There was a significant difference in the number of comments referring to other aspects of the animatronics, however (see Table 3). School groups at the animatronics asked questions and made knowledge statements, such as "I know this is a *Tyrannosaurus*," and mentioned anatomical features, such as legs, significantly more than family groups did. Furthermore, school groups also made significantly more comments about behaviors of the "animals" than families did. The following conversations are typical of the references to feeding and naming of the animals:

**Five-year-olds**
*Teacher: We are finally here. What do you think?*
*Boy: They're eating a big dinosaur.*
*Teacher: Do you know what they are called?*
*Boy: No.*
*Teacher: An animal that eats meat is a carnivore and one that eats plants is a herbivore.*
*Boy: They have eaten it.*

**Six-year-olds**
*Boy: Wow! Look, they are meat eaters!*
*Boy: Christopher, look they are meat eaters, aren't they?*
*Girl: They ain't very scaring.*
*Boy: Look at their claws!*

Here are two conversations at the exit model:

**Five-year-olds**
*Adult: Look, I think he just blinked.*
*Girl: He just opened his mouth a bit.*
*Girl 2 : Will he stand up I wonder? [laughter]*
*Girl 1: Look, he's moving his head.*
*Girl 2: He's moving back; he moved his leg.*
*Girl: Is he?*
*Girl 3: He did move it.*
*Teacher: What do you think he looks like?*
*Girl: A lizard.*

**Seven-year-olds**
*Teacher: It's not a dinosaur; it's a lizard.*
*Boy: I saw it move.*
*Girl: I think it's alive.*

Overall, both groups named the animals to a similar extent. The data suggest that more focused conversations on the animals by school groups occurred than with family groups, and the school groups asked more questions and contributed more knowledge themselves in their dialogues. The impression gained from observing and listening is that the story of either meat eater/plant eater or lizard-like animals came across to the visitors.

## Social Subgroups of the School Party

The data presented in Table 3 show that the content of conversations of the three social constituents of the school parties—(1) groups of pupils alone, (2) pupils with chaperones, and (3) pupils with teacher—are remarkably similar, except teacher-led groups make more comments about aspects of the exhibit.

**Table 3. Comparison of Content of Conversations Generated at Animated Models by the Three Social Subgroups Within School Parties (Main Categories)**

| Category | School Groups *n* = 422 # | % | Students Only *n* = 175 # | % | With Chaperone *n* = 113 # | % | With Teacher *n* = 134 # | % | $\chi^2$ Subtotal | Probability | Phi$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Management/ social | 304 | 72 | 122 | 70 | 83 | 74 | 98 | 73 | 0.65 | | |
| Exhibit access | 239 | 57 | 105 | 60 | 63 | 56 | 71 | 53 | 1.57 | | |
| Other exhibit | 173 | 41 | 82 | 47 | 22 | 20 | 69 | 52 | 44.60 | $p < 0.005$ | 0.11 |
| Body parts | 309 | 73 | 126 | 72 | 78 | 69 | 103 | 77 | 1.98 | | |
| Behavior | 363 | 86 | 146 | 83 | 95 | 84 | 121 | 90 | 3.31 | | |
| Naming | 176 | 42 | 61 | 35 | 54 | 48 | 61 | 46 | 4.36 | | |
| Affective attitudes | 229 | 63 | 99 | 57 | 62 | 54 | 68 | 51 | 1.06 | | |
| Emotive | 199 | 47 | 91 | 57 | 57 | 50 | 51 | 38 | 6.59 | | |
| Interpretative | 400 | 95 | 164 | 94 | 105 | 93 | 131 | 98 | 3.94 | | |
| Real/alive | 170 | 40 | 70 | 40 | 30 | 27 | 70 | 52 | 16.83 | $p < 0.005$ | 0.04 |
| Knowledge source | 339 | 80 | 134 | 77 | 89 | 79 | 116 | 87 | 5.04 | | |

All groups appeared to be able to find animals within the exhibits with similar success, and all the subgroups generated "exhibit access" comments in just over half of their conversations at exhibits. The groups with a teacher, however, commented significantly more about other aspects of the exhibit (e.g., the setting, the noise of insects, and whether the animals were real or alive), whereas the groups with a chaperone actually commented the least. All groups generated knowledge source comments, questions, or statements of knowledge to a similar extent, indicating that the exhibits are drawing the attention of all visitors to items equally successfully.

The comments generated by chaperone groups were more similar in numbers to those of the pupil groups without an adult than the groups with a teacher. An emphasis on animal observations—anatomical features and behaviors (see Figure 3)—characterize teacher-pupil and chaperone-pupil groups compared with chaperone groups who displayed significantly less interest in the authenticity of the animal specimens. The pupils with teachers commented significantly more ($p < 0.001$) about the dimensions—size, shape, color—of the dinosaurs and about the attracting behavior, which, in the case of the diorama, was the smaller dinosaur attacking the large dinosaur and, in the small single model, was moving its eyes and tail and making breathing movements. Groups used zoological names but did not justify their categorization with reasons. Significantly more ($p < 0.005$) of the groups with teachers identified the animals and categorized them (e.g., "It's a dinosaur"). Field observations were that many adults read the simple labels and found the scientific name of the animal and used that when students called the larger herbivore a *"Tyrannosaurus."*

The similarity on the range of comments suggests that the novelty and excellence of production and delivery of the robotics dinosaurs caught the attention of all the visitors. The teachers, through encouraging student observations, were able to elicit more comments from the students. These findings suggest that the exhibits did focus visitors to particular aspects of the exhibits and that the messages or story was "read."

## Interest of Age Groups

There was no difference in the content of conversations generated by pupils of seven years and younger and the older pupils except that younger pupils are significantly more interested in whether the robotics are real or not.

Children made comments about the movements of the animatronics, which prompted them to question the authenticity of the dinosaur models.

**Six-year-olds**
*Boy 1: They are so small and fierce.*
*Boy: Are these real?*
*Boy 1: No.*
*Boy:* Tyrannosaurus*!*
*Boy: Are those real?*
*Boy: No, they have metal inside them.*

This lack of differentiation and progression in the emphasis of the conversation of the two age groups, effectively Key Stage 1 (5 to 7 years) and Key Stage 2 (to 11 years, the end of elementary education in the UK), is a surprising result because if the pupils are experiencing a developing education, it is expected from the curriculum targets (DfEE, 1995) that the older pupils would have different interests from the younger pupils. The older pupils would be more focused on scientific observations, identifying, for example, both the vertebrate and the reptilian features of the models with reasons as well as observing and discussing adaptations to the habitat and way of life. An example would be giving reasons why the smaller meat eaters have claws and look as if they are built to run fast while the herbivore is much heavier and has little obvious means of defense.

## Discussion and Implications

A visit to the robotics animals could be a key incident in elementary students' learning about biology. The element of movement implicit in an animatronics exhibit interests the students (Heyman & Gelman, 2000). There is commonality of content of spontaneous conversations between the school and family groups, with but a few differences. This commonality is surprising. It suggests that schools may also have a social orientation, even if they do undertake the visit to a museum with a learning objective and that the learning aspects of the visit is not apparent through conversations generated at the exhibit. Furthermore, the two main messages at these particular animatronics are clear, well-delivered, and, hence, "read" by many visitors: (1) the fact that dinosaurs were reptiles with reptilian features should prompt the children to be able to group them in taxonomic category and recognize the salient feature upon which such classification is based, and (2) a predator has certain features and will hunt and eat prey. The following are examples of relevant comments:

**Classification**
*Teacher: What do you think he looks like?*
*Girl: A lizard.*

**Predator/Prey**
*Girl: Oh, look. They touched the blood, and they are eating it.*

The animatronics clearly showed salient features of reptiles: dry, scaly skin; the vertebrate pattern of post-anal tail; jaws with teeth; and that they were quadruped. When the message in an exhibit is vague and confused and the actual animatronics are the feature and not the story it tells, visitors miss it and the exhibits do not fulfill their role (Tunnicliffe, 1999). Hence, when arranging an educational visit, it is important to ensure that the animatronics are well-presented and not merely moving models just set down with little planning of a story line and supporting exhibitory to be seen. Animatronics must be well-made and exhibited in a context which reinforces their message.

Moreover, well-produced exhibits with robotic animals are even more effective in having the story inherent within their design be "read" by the pupils (Tunnicliffe, 1996c). If the visitors are attending to the story that is being portrayed through the museum exhibit, it is important to find out if they are commenting on other aspects of the exhibit besides the animal specimens. Table 4 shows the occurrence within the total conversations of those in which a comment about another aspect of the exhibit, other than the animal specimens, was mentioned at least once.

**Table 4. A Comparison of the Occurrence of a Comment About a Topic That Occurs at Least Once in a Conversation by Age Group 1 (Seven-Year-Olds and Younger) and Their Accompanying Adults**

| Category of Conversation | Animated Models Seven Years and Younger $n = 271$ # | % | Animated Models Eight to Twelve Years $n = 151$ # | % | $\chi^2$ (1 df) | Probability | Phi² |
|---|---|---|---|---|---|---|---|
| Exhibit access | 146 | 54 | 93 | 62 | 2.35 | | |
| All exhibit comments | 136 | 50 | 71 | 47 | 0.39 | | |
| Management/social | 194 | 72 | 110 | 73 | 0.08 | | |
| Body parts | 193 | 71 | 116 | 77 | 1.55 | | |
| All behavior | 237 | 88 | 126 | 83 | 1.30 | | |
| All naming | 119 | 44 | 57 | 38 | 1.52 | | |
| Affective attitudes | 140 | 52 | 89 | 59 | 2.07 | | |
| Emotive | 121 | 45 | 78 | 52 | 1.91 | | |
| Interpretative | 258 | 95 | 142 | 94 | 0.27 | | |
| Real/alive | 95 | 35 | 30 | 20 | 10.73 | $p < 0.005$ | 0.03 |
| Knowledge source | 221 | 82 | 118 | 78 | 0.71 | | |

There is little "talking science" (Lemke, 1990) of predicting, hypothesizing design observational protocols, gathering data, and evaluating it (Tunnicliffe, 1996b). While this is, perhaps, an acceptable state of affairs for families whose educational aspiration of the visit, if any, is likely to be to see a range of animals, it is not so for schools when children are visiting as part of their curriculum entitlement to introduce or reinforce some of their science learning. This includes not only knowledge and understanding of animal groups but also the process of science and general aspects such as care for the environment and communication (DfEE, 1995). Students are not asked to make predictions based on a set of observations or previous work carried out in school and then find out from further observations whether their prediction is valid. Biology in the initial stage of learning is above all an active observational science and, as Klahr (2000) points out, the first stage of science, inquiry, is based on observation. Moreover, Tomkins and Tunnicliffe (2001) found that if students can look for meaning while they observe, they will begin to ask inquiry questions. Lemke's "talking science" is not necessarily the way of "talking biology," which requires scaffolding on the part of the exhibit, teacher, and chaperones. Such scaffolding was not evident in the conversations studied. The children's queries were answered, but they were not invited either to explain their comments, justify their categorization of animals and behaviors, or raise hypotheses and work out answers.

The data do show that children and adults make similar observations and name the animals. Such comments reveal that there is a basis from these comments for developing *biological looking*, which involves recognizing patterns and relationships of structures to behavior. Such observations provide a basis for the type of work which could be developed by teachers and museum workers at such exhibits as well as the inquiry process that defines the science process as expected to be learned by schoolchildren (DfEE, 1995). Hence, "science talk" with animal specimens could be developed (Tunnicliffe, 1996b). If teachers and museum educators were aware of the differences in conversational content that reflect interest, and the differences that exist between the genders, age groups, and the various socially composed groups of school parties, they could take measures to use the interest in the groups possessing it and develop it in those groups that do not show the interest. Moreover, these interests could be channeled into effective zoology learning rather than casual comments.

The two animatronic exhibits discussed in this report had a clear message—predator-prey and similarity to living reptiles—which enabled the visitors to link their knowledge with the message inherent within the exhibit. Thus, museum educators, through their skill in exhibit design, can assist in the learning of fundamental biological concepts such as herbivore vs. carnivore and the similarity of dinosaurs to living lizards. The data show that groups with teachers achieve a higher content in their conversations about anatomical and behavioral features. However, there are implications for preparing chaperones to fulfill this role, and they need to be assimilated and acted upon because the chaperone groups did not have this same emphasis within their conversations. If chaperones are not effectively prepared, the pupils in their charge are deprived of the educational experience to which they are entitled. The exhibit alone cannot "scaffold" an expert to guide the students and give the pertinent previous knowledge to the students that is required.

One of the functions of natural history museums inherent within their educational mission, whose foundations lie in identification of specimens and recognition of criterial attributes, is to develop public understanding of biological science. We have to consider the extent to which viewing robotics animals enables visitors to attend to these issues and whether the messages explicit within the exhibits reach the visitors. Also to be considered is the value of listening to and analyzing the unsolicited conversations of visitors. In the case of dinosaurs, the answer is that visitors attend to and receive the story that the museum is telling, which is simple, yet skillfully told. School groups, overall, attend to the anatomical and behavioral characteristics manifested in the exhibits significantly more than the families did, and they asked more questions and made more statements of knowledge within their groups than families did. Again, this is an indication that the exhibit alone is not doing the teaching. Teachers, in particular, use scientific concepts, which scaffold the children's learning. The animatronics have a simple, well-thought-out story line, which is "read" by the visitors. Thus, the public is developing an understanding of some basic biological concepts through these exhibits, albeit at the level of meat eaters, plant eaters, and reptilian features, and they do focus on these topics while they look at the models. However, animatronics, per se, are not the answer (Tunnicliffe, 1999); they have to be skillfully constructed and placed within a well-thought-out context, which helps to deliver the story line.

There are several messages here for institutions considering using animatronics. First, the models must be well-made and set within a meaningful context. Second, the story line must be simple and very clear. Third, different social groups have different needs in terms of assisted interpretation. Such help should be available in various forms. At present, educational programmers make allowances for gender, age, and social composition of the groups in which students work when within the museum. It is clear that the influence of the adult on the conversational content of the students is important, and different groups need a different emphasis in preparation and interpretation. The baseline analysis of the content of conversations at robotics provided by this study can be used to develop the science education offered within museums by both the museum and the schools who bring their students to it. Each side can make provisions and allowances for the different levels of interest in gender groups and the age of the pupils so that a progression in content of observations is developed. Museum visits should not be missed educational opportunities (Tunnicliffe, Lucas, & Osborne, 1997), they should be part of the ongoing development of the public or civic understanding of science and students' biological concept construction as well as an enjoyable social experience. Animatronics can contribute to achieving these goals.

## Endnote

[1] Key Stage 3 is a stage of education in England, Wales, and Northern Ireland for the first three years of secondary school, 11 to 14 years old. Key Stage 4 is the last compulsory stage, 14 to 16 years old, when they take the leaving exams, GCSES.

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