

How Families Use Questions at Dioramas: Ideas for Exhibit Design

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ABSTRACT This paper explores the role of questioning in scientific meaning-making as families talk, look and gesture in front of realistic and artful dioramas at the Natural History Museum of Los Angeles County. The focus is on the ways questioning can either enable movement towards scientific understanding or hinder such progress. The socio-cultural framework of this research emphasizes Vygotsky's interpretation of the zone of proximal development (*zpd*). Questions are viewed as tools for mediation in the *zpd*. This paper examines three families' dialogues, excerpted from a larger study of collaborative sense-making among family groups in a natural history museum. It seeks to understand how collaborative dialogue meshes everyday understandings with canonical science, in this case through the use of questions.

INTRODUCTION

This paper focuses on the role of questioning in scientific meaning-making by examining conversations that took place in front of the classic dioramas in the Natural History Museum of Los Angeles County, specifically in the acclaimed North American Halls. By following the conversations of three families, selected from a sample of 15 families, it's possible to determine how families use questions to make sense of their experiences. Sense-making conversations, in this context, are socially-structured discourses in which groups of individuals with different levels of knowledge (also known as distributed expertise; see Brown, Ash, Rutherford, Nakagawa, Gordon and Campione 1993) share dialogue about scientifically meaningful material over a sustained period of time.

Raising questions at dioramas is not unusual. After all, dioramas realistically represent scenes of animal and plant species in natural habitats. Dioramas were historically designed to evoke feelings, thoughts and perhaps memories, and to promote an ethic for the preservation of species and their habitats in the wild, including the conservation of animals and places that most people will never view. Learners are stimulated by the dio-

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ramas to watch, point, seek more information, and ask questions. As they begin to link their own lived experiences with the artifacts in the dioramas, they may even personalize concepts like habitat and species conservation. All this occurs through observations, questions, and explanations and other processes.

As a learning researcher I am curious to understand how questions can advance or hinder sense-making, and how this information can help with the design of better tools for dialogue mediation in museum settings. Questioning is one assessment tool that can be used to analyze how families interact with material objects and with each other through dialogue. In the course of this constantly changing process, meaning and knowing are ceaselessly negotiated in interactions with the material world. Questioning is also a method for advancing scientific meaning in a social setting.

As a researcher of scientific sense-making, I am interested in understanding how this type of research can contribute to the practical issue of designing exhibits that are family-friendly and that foster productive questions, explanations and predictions. In short, what can collaborative conversations among learners with different kinds of knowledge tell us about design?

As a biologist, I am curious to determine how dioramas are useful for generating biological concepts, themes and reasoning methods. Past research has shown that content-driven themes—such as feeding, breeding, and protection from predators—are common and necessary ingredients of biological conversations in museums and classrooms (Ash 2002; Brown, Ash, Rutherford, Nakagawa, Gordon and Campione 1993). Such content themes have also proven to be the organizing principles of everyday understandings that family members bring to informal learning settings.

FAMILY LEARNING RESEARCH

It is not new to study family interactions in museums. Past research by Diamond (1986), Dierking, Luke, Foat and Adelman (2001), Dierking (1989), and McManus (1989, 1994) have all provided valuable insights. As part of the NSF-funded Philadelphia/Camden Informal Science Education Collaborative (PISEC), Borun and Dritsas (1997) suggested seven characteristics of successful family learning activity at exhibits, including: multi-sided, multi-user, accessible to both children and adults, served by easily readable text, and relevant to visitors' existing knowledge or experience. More recently, *Learning Conversations in Museums*, sponsored by the Museum Learning Collaborative (Leinhardt, Crowley and Knutson 2002), has offered several new accounts of family collaborative activity in informal settings. See in particular Ash (2002) and Ellenbogen (2002).

Other researchers have explored the dialogic tools parents and children use to develop collaborative scientific understandings. Callanan, Shrager and Moore described methods for observing, identifying and analyzing explanations in the everyday discourse between young children and their parents (1995, 105–129). This research focused on the interactive nature of explanations as a way of identifying learning in a social context, and showed that the most common types of explanations were those that were both initiated

and completed by parents. Gleason and Schauble (2000) explored the types and functions of process skills, specifically parents' analyzing and synthesizing at a science exhibit centered on water. These studies and others have provided the essential foundation for the work described in this paper.

There have also been studies about the role of questioning in school settings (Harlen 1996; Nystrand 1997; van Zee, Iwasyk, Kurose, Simpson and Wild 2001). Van Zee provided a useful taxonomy for the types of questions that most commonly arise in classroom settings. To date there has been little research exploring the role of questions in advancing meaning in informal places of learning, such as natural history museums, aquariums or discovery centers.

Questioning in the *zpd*—This research concentrates on questioning at dioramas. It is expected that each learner's knowledge and skill set is different, and that, in social learning settings, each person contributes according to ability, and is changed by interactions with others. Vygotsky (1978) emphasized the inherently social nature of learning through his construct, the "zone of proximal development" (*zpd*) which has been described as "the zone in which an individual is able to achieve more with assistance than he or she can manage alone" (Wells 1999, 4). This theoretical interpretation is not new to classroom learning research but it is reasonably new to diorama research and to research at other types of exhibits in informal settings.

I saw such sense-making occur many years ago, during an aquarium visit. A family had gathered at an aquarium tank with several peepholes at different levels. Each family member could see only through his or her peephole. As family members gathered at the aquarium, they helped one another discover what was in the tank, what processes might be occurring and how to make sense of it all by talking to, pointing and showing each other. This image of differential peepholes into different knowledge areas is a metaphor for the family visit. At any exhibit, each learner views something different, something more or less unique. Learning is based on past experience and current activity, but does not occur in isolation. As different members share their expertise, their distributed knowledge, their different peepholes, they are in effect "working in the *zpd*" (Ash and Levitt 2003; Vygotsky 1987).

This paper examines how questions help clarify each family member's view through a particular peephole and what this may teach us about research and exhibit design.

The learning setting: Dioramas—Dioramas depict real, non-living animals placed within a simulation of their natural habitat. Many of these objects were once alive; thus they represent a natural reality and they encourage a personal experience with nature. In fact, they are a simulated first-order experience. Dioramas also represent a sort of cultural tourism, in which people can feel they are part of the scene, the event or the habitat (Paris 2002).

Dioramas were originally intended to allow people with no access to nature to see animals exhibited in their natural habitat. The motivation for this exposure to animals in situ was to educate the public about the world "so that they would be more willing to sup-

port projects to preserve the environment” (Flannery 1998). Through dioramas, objects are immediately accessible for direct interpretation, and are separated from verbal, written or gestural cues or from an intermediary. Even the youngest child can imagine itself in one of these settings.

Dioramas also provide a different kind of experience than the physical one found in hands-on museums and discovery centers. At dioramas, visitors focus on observation, rather than physical manipulation of objects. Observing complex arrangements of objects in realistic dioramas demands specialized skills. Often, verbal interaction takes the place of physical interaction. This pattern is markedly similar to the way a naturalist visits a new ecosystem. The naturalist must determine patterns of adaptations within complex environmental constraints. Similarly, students visiting a polar bear diorama and a black bear diorama in the same exhibit hall may notice the presence of fur on both sets of animals, but they may conclude that color matters as well.

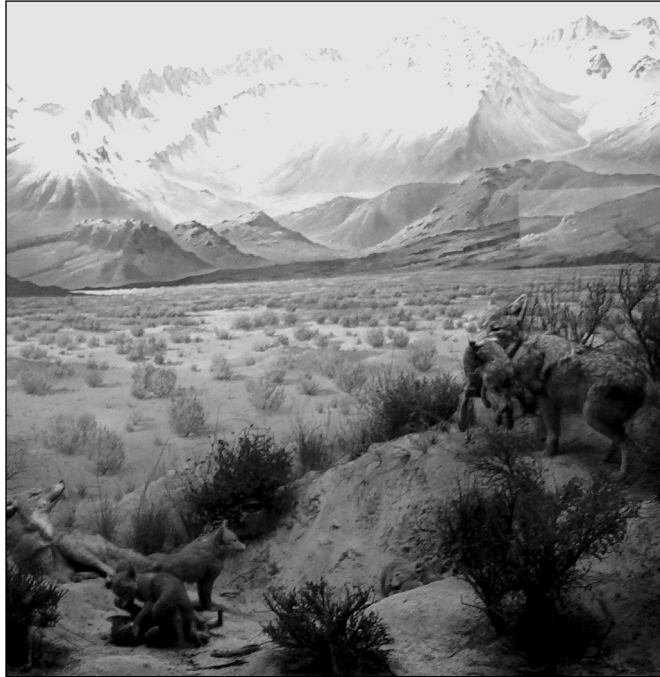
Dioramas allow us to connect everyday experiences with the more formal taxonomic structures of science, by inviting visitors into a realistic atmosphere where one can imagine oneself in the African bush or on a rocky coast. Because of the diverse intellectual demands on observers, dioramas are an ideal setting for social groups of all ages and backgrounds to gather, look, point, name, and discuss how animals live and behave, and to wonder how these animals might be adapted to their environments. Past research on dioramas (Cone and Kendall 1978; Flannery 1998; Korenic 1998) has not focused on scientific sense-making, nor on analyzing detailed dialogic data. However there is a growing body of non-classroom research (Ash 2003; Crowley and Callanan 1998; Ellenbogen 2002; McManus 1989, 1994; Schauble, Beane, Coates, Martin and Sterling 1996) focusing on sense-making processes in informal settings, which informs current diorama research.

Similarly, there is a growing field of research emphasizing the role of objects in learning settings. A recent text edited by Scott Paris has given valuable insights about an object-based epistemology (Conn 1998), and what object-centered learning entails (Paris 2002). Particularly important to the research reported in Paris’s paper is the intersection of discourse and object. As Paris has said, objects are the “stimulus for conversations, and explorations, and a beginning point for discourses that may be scientific, historical, aesthetic, or personal. . . . There is a great deal to learn about how people talk about objects, and about how objects foster question asking and answering” (2002, xvii).

Dioramas invite questions. Harlen (1996), Nystrand (1997), Wells (1999) and van Zee et al (2001) have discussed the role of questions in the classroom context, focusing on the ways questions are asked and answered. Harlen (1996) has broadly divided questions into two categories: open and closed. Questions such as “Can you tell me more about that?” and “Why do you think the plants have those dots on them?” are open-ended. Closed questions are typically answered with “yes” or “no” and do not provide an opportunity for further dialogue.

Others (Lemke 1990; Gallas 1995) have discussed known-answer questions, which are familiar in the classroom setting, and have been described as the typical IRF (Initiate, Respond, Feedback) sequence. For example:

Coyote diorama at the Natural History Museum of Los Angeles County. Photo by Jeremy Price, courtesy of the Natural History Museum of Los Angeles County.



Initiate: What is that thing with the large horn?

Response: That's that male deer.

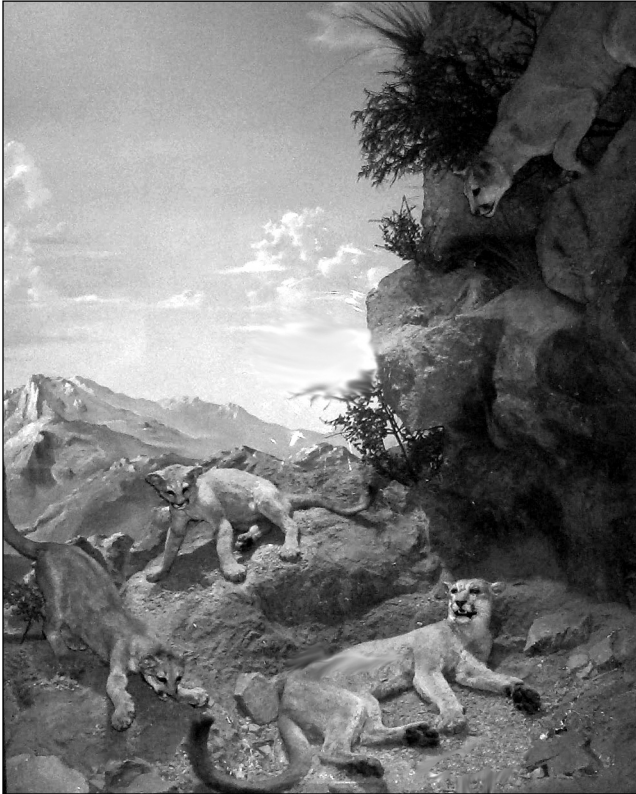
Feedback: That's right, good!

The feedback response can vary greatly in how it is handled; this determines the possibilities for further conversation. For example, a parent, rather than merely accepting or rejecting a response, can attempt to reformulate or expand it, thus exploring the range of understanding (*zpd*) for that particular content area or activity.

Noting sequences of questions in family conversations can prove helpful in uncovering the role of questions within larger dialogue segments, especially by examining the type of feedback that occurs when questions are asked. We can analyze how question sequences evolve over time and how they function in sense-making activities. Questions can be openings or potentials for dialogue, functioning as invitations that may or may not be accepted.

METHOD

The focus in this paper is restricted to transcribed audio- and videotaped dialogues of three English-speaking families (out of dozens of families we have worked with at the Natural History Museum of Los Angeles County over the last three years). This is a small



Mountain lion diorama at the Natural History Museum of Los Angeles County. Photo by Jeremy Price, courtesy of the Natural History Museum of Los Angeles County.

data set, thus the results are not representative. Yet they substantiate the usefulness of focusing on questioning in detailed dialogic analysis.

The families in this study consisted of two to five mixed-age members, with at least one parent and one child ranging in age from four to eight years. Each family chose the order in which to visit the dioramas. Individual visits lasted from 30 to 90 minutes, and were mediated by a member of the Natural History Museum staff. Each North American exhibit hall had at least a dozen large dioramas portraying animals and their habitats in realistic fashion. Many of the painted habitats behind the animals were particularly vivid. Every family visited at least one of the two halls.

This system for dialogic data analysis has three levels. The first level is in the form of a flow chart, which provides an overview of one entire visit (typically 40–60 minutes), as well as the pre- and post-interviews (15–20 minutes each). The second level is an intermediate analysis, here termed the Significant Event (SE) (Ash 2002). Each Significant Event represents one segment of the flow chart analyzed in greater detail, emphasizing dialogue, content and the kinds of tools the groups used to make sense of science and to connect it to their prior understanding. The third level is a detailed Dialogic Analysis. This third level analyzes particular SEs in greater detail, ideally by using the myriad details available from video data, such as dialogue, gestures, gaze and actions.

The flow chart provides a mechanism for scanning a complex series of episodes in terms of continuity of dialogue, biological themes, and frequency and type of questions. It suggests segments for in-depth analysis; it also provides a visual map of how each family moves through the museum. A series of activities may appear only loosely coupled, yet over time they may reveal an internal logic. Following are abbreviated segments of flow charts for three family visits.

Family 1: The Barnetts—The Barnetts consisted of a four-year-old girl, Mary, and her father. Their entire visit lasted 30 minutes, after the short pre-interview. They are not frequent museum-goers, and this was their first visit to the Natural History Museum of Los Angeles County.

At the beginning of this particular segment, Mary and her father stood in front of the Grizzly Bear diorama in the North American Hall. This diorama features a group of approximately six bears of varying sizes. The father read the sign to his daughter, and identified animals in the diorama. He pointed and asked a few questions. At time marker 29.50–32.00, the father asked Mary if they saw bears when they were at Bass Lake. He was trying to link the animal in this diorama to their joint prior experience. His question, which was meant to engage Mary in conversation, was not particularly successful. So they moved on to the Polar Bears (time marker: 32.00–33.01). Here, Mary had a lot to say.

Looking at the group of animals gathered on the ice and snow, Mary said, “The mother is first.” (An adult bear was closest to the front window.) The father read the sign and identified the animals, then asked several “do you see... is that a...” type questions. Mary expressed the desire to go inside the exhibit, clearly thinking something different than her father. Her father said, “No, do you know how much it weighs? As much as daddy.” Here the father referred to the bear’s weight as a way of inferring danger, thus promoting the notion that these animals are alive.

Mary already had indicated that she knew animals in dioramas were not really alive, thus her father’s suggestion confused her. She used personification, while her father intentionally confused alive versus dead. Personification is the mapping of human characteristics to animals according to the perceived degree of taxonomic closeness (Carey 1985; Hatano and Inagaki, 1993). For example, worms would not be taxonomically close to humans, but bears would. This conversation also touches thematically on the notion of alive versus dead, a tension that is typical for most young children at dioramas. The father’s questioning was open-ended and allowed for either limited or broader responses from Mary.

Mr. Barnett attempted to connect Mary’s current experience to vacation experiences they had shared. His questions primarily functioned as an invitation to further dialogue. He asked one or two questions per exhibit, without pressing or hurrying. He matched his pace to Mary’s. At the Polar Bears, as he attempted again to cue her experience by asking about the bears’ weight, he attempted to personalize her experience at the dioramas. He hinted that these bears can behave like live animals and Mary was confused. Later, the father did not respond to Mary’s salient, and quite typical, question about whether these animals were alive or dead. This is an especially captivating issue for

learners of all ages. Mr. Barnett might have been able to use cues from exhibit designers—through exhibit labels, for instance—to help his daughter mobilize her own ideas to make sense of the dioramas. One question asked by many children is how these animals in dioramas are collected and stuffed.

Family 2: The Schindlers—This family consisted of the mother, father and four-year old twin boys Bob and Ken. The visit lasted 42 minutes. The Schindlers are a museum-going family whose children are home-schooled. The mother uses museums as a teaching tool and had already brought the boys to this museum two weeks prior to this visit. During the pre-interview the mother explained that her teaching strategy was to introduce information and let her boys get the big picture on a first visit, then revisit for follow-up learning. She believes that the revisits reinforce prior experiences. The mother and father had each come to the Natural History Museum as children 20 years earlier, and felt it was a special place for them. The mother likes to see animals in their habitats, and thus found the dioramas very helpful.

At the Polar Bear diorama (time marker: 1:11–1:130), the Schindler mother read information from a card provided by the exhibit. She questioned the boys, “What do you think they eat?” Bob said, “Seal,” and the mother asked: “Why do you think it’s important that he has fur on its back?” Bob said, “To keep warm.” These may appear to be open-ended questions, yet a specific answer seemed expected. The mother then asked the boys to notice the similarities and differences between polar, black and grizzly bears.

The mother was the most active agent. She read, offered information to the boys, and prompted them with factual questions. The boys did not initiate dialogue as had Mary Barnett, the daughter of the family described above.

In the Schindlers’ dialogue, questions followed one another in succession and were quickly answered, either by the children or by the parents. Then the group immediately moved on to something new. The mother allowed little time for the boys to stop or to consider another possibility before an adult answered. Questions met the standard IRF format, and rarely were genuine invitations to further conversation. The irony is that the Schindlers use much complex content in their questions, and the children have learned to respond with correct answers at a very young age; they know what is expected. However, questions seem to function as a check for prior understanding. There were many questions per unit of time throughout the entire visit.

Family 3: The Linds—The Linds are not a museum-going family; however, the two girls (ages eight and nine) had been to the Natural History Museum of Los Angeles County twice on school visits. This was the first visit for the father, mother and son (age four). The girls were especially interested in dioramas, because: “They are real animals behind the glass. They stand still, [unlike] in the wild, [they] can’t attack, [so we are] safe. You can see them, [they are] not camouflaged.”

At the Grizzly Bear exhibit (time: 12.05–13.0), the son Jan said, “They look real.” Margie said, “They are real; they are stuffed.” The mother said, “Really?” She asked her son, “Does it look like a family, what do you think?” The mother also asked her son,

“What kind of bears are these?” and answered her own question, saying “grizzly bears.” The father said, “Look at the paw.” The mother followed, saying, “What do you think about that paw, Jan?”

As with the Schindlers, there were quite a few questions, but this family did not seem to carry the same expectation of a quick or definite answer. The questions seemed genuinely open-ended.

This short episode was typical for this family’s visit. The mother asked most of the questions; she focused on cueing information for the boy, Jan, and the two older girls. The mother’s questioning style typically opened up talk and invited further thinking. She used the exhibit labels well, integrating them into the conversation. Her pace was slow and deliberate. Throughout the Linds’ visit the youngest child remained interested, due in large part to the mother’s ability to meet the children at their own levels of expertise. The Lind family’s visit offers useful examples of specific dialogic patterns that unfold during a portion of dialogue at the Mountain Sheep diorama, segment 1.

Mountain Sheep Exhibit (Video time 14:12–15:16):

Marg: That’s the dad.

Meg: And that’s another dad.

Marg: Yeah that’s the dad.

Mom: That’s the dad?

Follow-up question that builds on prior statement and invites personification.

Meg: You can tell.

Mom: How do you know?

Open-ended question invites explanation.

Meg: Because of its big horns.

Mom: Yeah.

Marg: And then all, that’s the mom and then that’s the pups.

Meg: That’s the baby.

Mom: That’s the baby?

Open-ended question builds on prior statement and personification.

Marg: Yeah.

Mom: Is that the youngest baby?

Open-ended question builds on prior statement and personification; invites explanation.

Marg: That’s the oldest and then that one and then that one.

This expanded view of Mrs. Lind’s questioning pattern reveals an open and responsive questioning technique with all three children and thereby engages the whole group. She picks up the children’s reasoning, especially person-analogies or personification, and employs it herself. Her questions act as invitations for observations, and are keyed to the

children's statements. Mrs. Lind meets the children at their current level of understanding, while notching up the content level opportunistically.

The family continues their group dialogue about personification 30 minutes later in segment 2.

Wolverine Exhibit (Video time 47:58–48:51):

Son: *Look it, look at that baby.*

Marg: *It's not a baby, it's a squirrel.*

.....

Mom: *You know . . . what do you think is happening right now?*

Open-ended question invites explanation.

Marg: *He's trying to, he's trying to...he's gonna climb up, all the way . . . till he gets the flying squirrel.*

Meg: *No.*

Marg: *Yeah.*

Mom: *Flying squirrel . . . how do you know?*

Open-ended question builds on prior statement.

Marg: *Yeah, yeah, it's a flying squirrel . . . yeah, because it . . . their hands are webbed and then they jump and it looks like they're flying.*

Mom: *Oh really?*

Follow-up question builds on prior statement.

In segment 2, the son points and says, "Look it, look at that baby." Meg says, "It's not a baby, it's a squirrel." The mother's questioning prompts the girls to describe what is happening in the diorama, which moves the conversation forward in a direct and collaborative fashion.

In both segments the children used personification as a scientific reasoning tool. They gave animals family-role labels, such as Mom, Dad and Baby, relying on external features. For example, the largest big-horned sheep was identified as the father, while the smaller sheep were called babies. In the absence of other information, this is a starting point for children's scientific understanding. Children assume that particular physical features, like size or horns, have particular purposes. This form/function reasoning (Ash 2002, 2003) is very useful in building children's early understanding of biological characteristics. Meg and Marg comment, "That's the dad" and "That's another dad." Mrs. Lind asks, "How do you know?" Meg answers, "Because of its big horns." The girls assume that bigger horns mean that male gender maps onto larger size or specific male features for humans and many other animals. This coupling of form/function reasoning with personification is quite typical for younger learners, and is potentially a useful tool in designing dioramas. For non-experts, these ideas provide a foundation for making sense of what

is included in the scene. Personification was also used in other exhibits, including the wolverine exhibit, when the smaller creatures were assumed to be babies.

Throughout their visit, the Linds often started with a question that matched the current state of the children's knowledge. The mother referred to, challenged or reflected on the children's knowledge in order to help them clarify their thinking and also to scaffold their understanding. This "working the *zpd*" can seem quite invisible, especially when interwoven as part of the social fabric of the family dialogue. Through careful analyses over time, however, subtle questioning patterns can be seen.

DISCUSSION

Each family used questions in these diorama dialogues. There are three main characteristics of this process:

1. Families create a loosely coupled pattern of discernable but discontinuous events, during which members attempt to make sense of what they see, using biological themes such as alive/dead, feeding and life cycles, as well as personification and form/function reasoning to establish the everyday antecedents to more scientific ways of thinking.
2. Within the discernable but discontinuous events, family members, especially parents, use a variety of questioning strategies that invite children to co-construct meaning.
3. Questioning strategies that invite others into the ongoing dialogue sustain biological themes over discontinuous events. Such strategies include using prior knowledge, open-ended questions, and questions inviting further explanation.

As each family proceeded through the dioramas, the implicit goal was to question, organize and orchestrate the group's thinking, talking and actions. This pattern cannot become apparent if only a portion of the talk is analyzed. Yet if the entire visit is subjected to sequential analysis, a loosely coupled structure becomes evident across all the dialogues and activities.

All three families used biologically-based thematic content at the dioramas, just as other families have done in museums and aquariums (Ash 2002; 2003; Ash and Wells in press). Such ubiquitous themes center on basic biological categories such as feeding, breeding, protection from predators and from the elements; or they evolve around the qualities of living things, based on distinctions of alive versus dead, or real versus man-made.

Parents who adopt successful teaching and learning strategies use questioning to explore these themes and related reasoning patterns in order to enhance their children's understanding. One such reasoning pattern is personification, also called person analogy. In all three families, children identified certain of the animal figures as the moms, dads,

and babies. The parents did not correct their children, but rather augmented what their children said, mapping human characteristics onto each animal. All family members used gender and age mapping based on characteristics common to humans and animals, such as size. This is consistent with prior research (Ash 2002), which found that personification can be a powerful tool for understanding and organizing novel material. While personification is not entirely correct, it is not entirely incorrect, either.

An increasingly robust body of knowledge suggests that seemingly simple entry points to scientific material, such as “How does this eat?” or “There’s the dad!” provide important underpinnings for family dialogues and serve as the “necessary antecedents” for acquiring more scientific ways of reasoning. While they may appear simple or non-scientific, it is precisely through these entry points that biological pattern-building episodes emerge in dialogues and establish the foundation for increasingly complex understandings.

Questioning strategies—These families frequently asked questions. The questioning process served as a mediational strategy for family members to facilitate understanding. Some questioning strategies worked; some did not. To “work” is to move the conversation forward and toward the scientific. The most effective questioning strategies allowed some families to “work in the *zpd*,” during which parents effectively assessed the learner’s understanding and then provided a linguistic thematic cue that helped move understanding forward. This is, in fact, a form of formative assessment (Ash and Levitt 2003).

A second equally important feature of questions is that they invite co-construction of seemingly simple biological themes. We noted that questioning is ubiquitous; yet questions are neither as random as they seem, nor equally efficacious for learning. Questions have different forms and particular functions that follow from these forms. Thus, as families approach a new activity area, some types of questions, such as genuinely open-ended ones, can encourage more conversational opportunities. This research has enabled us to begin to discern these different forms and functions, primarily regarding connective and evocative functions. Genuinely open-ended questions do not demand quick or predetermined answers.

Questions also evoke connections with something or someone already known, thus tapping into prior experiences and personal memory. Paris has suggested that dioramas “recreate the past/present, and give opportunities to tell stories” (2000, 3). This strategy seems to work equally well, whether initiated by parents or children. Although parents and children have different experiences and parents generally know more, children readily become experts in certain areas. Children can be informed through TV, school and reading. In all three families, the parents used prior knowledge, acting as their children’s teachers while actively seeking ways to engage and maintain their children’s interest. Prior knowledge does not have to be old to be useful. The Lind family dialogues showed how certain types of knowledge and certain strategies can be appropriated and adapted even as a family moves through a single exhibit.

Questions can also open up dialogue or shut it down. Questions set up what follows and reverberate over the course of the dialogue. When questioning works well, dialogue is maintained, other people are invited into the conversation, and new points of view are

solicited. When it does not, conversations die. It is parents' job as teachers to assess their children's current level of understanding and to match their linguistic moves to that level. This research suggests that parents look for evidence of what their children are learning and then fine-tune their actions to their children's current level. Thus, questions are a primary tool for pairing assessment of understanding with an appropriate and matched action by parents. While questions may appear to be used opportunistically, sequential analyses reveal that they can be quite finely tuned to the child's current state of knowledge and to the next possible step of learning.

The parent (teacher) who is "working in the *zpd*" constantly attempts to increase the learner's level of knowledge, as soon as the learner indicates a readiness to receive it. The dilemma, of course, is discerning the child's readiness to do so. The Schindlers offered many interesting questions, but at a rapid, staccato pace. These questions often did match the children's current state of understanding, but the tempo did not give the children a chance to respond to individual questions in a deliberate fashion. The parents often answered their own questions, instead, or moved on to new material, leaving the questions hanging. This type of questioning behavior is commonly found in classroom settings. Such examples of didactic interactions in family dialogue may, in fact, be more common than the finely tuned "working in the *zpd*" dialogues.

IDEAS FOR DESIGN

It is obvious that we need to offer exhibits that are multi-sided, multi-user, accessible to both children and adults, served by easily readable text, and relevant to visitors' existing knowledge or experience (Borun and Dritsas 1997). These design points are given. Next we need to understand in detail what actually occurs when these design features are provided. We also need to understand the role of questions, explanations and predictions within that process, assuming that questions originate from a number of sources, including family members, docents or signage. Thus the challenge for both researchers and museum professionals is to design the next generation of exhibits and research so that we can begin to determine how tools—such as questions—are used in the *zpd*. These efforts can provide new information allowing us to redesign exhibits in an iterative fashion, providing further opportunities for productive questioning and for collaborative discourse. These in turn will inform our views of learning. These kinds of design-experiment research are just now being undertaken (Brown 1992).

As yet we do not understand learning in museums; we have seen only glimpses of where next to look. The ideas offered here center on existing tensions concerning research and exhibit design, two reciprocally intertwined areas which merit investigation in order to think about what actually occurs in the *zpd*. Working in the *zpd* is not yet a common notion for exhibit development. We must think of new ways to engineer exhibit and research design to study these reciprocal interactions. We will need more and better research to accompany these new understandings. The family dialogues illustrated here provide several places to start this work.

Designing for multiple entry points—Using the peephole metaphor and the diorama research discussed in this paper as guides, we can briefly discuss one of these starting points: designing for multiple entry points using fundamental scientific themes.

The first experiments in research and exhibit design might focus on providing authentic multiple entry points for learners with different levels of expertise. This does not mean merely providing many different peepholes; it means providing peepholes that tap into the different kinds of understandings, so that learners of all ages can find compelling areas of interest. Our challenge is to determine what these authentic multiple entry points look like. There are several clues. The first clue is the observation that thematic scientific content and principled ideas in biology attract all learners. For example, we know that children want to raise the “alive versus dead” and “real versus not-real” issues in diorama settings. Why not address these interests directly, and begin to build on characteristics of “living versus stuffed” animals? We know that parents are interested in the same things as their children; they want to know enough to scaffold their children’s motivation to learn. Why not provide parents with the kinds of ideas, questions, explanations and other prompts that allow them to help their children build scientific understanding?

Dioramas provide an ideal opportunity to design multiple entry points, because family members know different things. Exhibit design offering multiple opportunities for family dialogues will greatly enhance family interactions. Prompts and signs can start at the beginning, for novice learners, by providing insights about basic categories, such as “animal versus plant.” This is not a “dumbing down” of content, but rather taps into the fundamental themes and interests of most learners. Families working in the *zpd* need to have stimuli that act like peepholes into each learner’s level of readiness. Simultaneously, material may be aimed at more expert learners’ *zpd*: for example, exploring issues of taxonomy or more specialized adaptations. Enduring ideas are, as Bruner suggested, “lithe and lively” and immensely interesting at many different levels, for many different ages (1990). We know these “lively” ideas can be revisited in many different contexts. It would be a useful design activity to determine how the same enduring idea, such as “alive versus dead,” can be scaffolded for learners of all ages at one diorama hall.

This type of scaffolding and multiple entry point design can also promote the effectiveness of parents as teachers. Because parents are such natural and life-long teachers of their children, the results of analyses of actual dialogues between parents and children can help us design exhibits in ways that augment their talents. By analyzing questions over time, we can begin to see how individual questions drive talk, and how they can help parents accomplish their teaching and learning goals.

This data, though based on a limited sampling of families, provides evidence that meaning making is at the heart of the museum experience, and that questions are one tool by which this is accomplished. The framework of the zone of proximal development is useful for viewing how families co-construct scientific understanding with their children in informal learning settings. With a strong theoretical foundation and careful analysis of dialogues in informal settings, we can begin to understand how better to design exhibits to enhance the more effective strategies and how to guide parents to adopt them.

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