Distributed Expertise in a Science Center
Social and Intellectual Role-Taking by Families

Heather Toomey Zimmerman, Suzanne Reeve, and Philip Bell

Abstract This research project examines the way that children and parents talk about science outside of school and, specifically, how they show distributed expertise about biological topics during visits to a science center. We adopt a theoretical framework that looks at learning on three interweaving planes: individual, social, and cultural (tools, language, worldviews, and artifacts). We analyze conversations to study how these three planes show learning processes as families work together to create explanations of biological phenomena. Findings include: (a) children and parents made epistemic moves that led to different social and intellectual roles in the conversations (skeptic, expert, memory-prompter), sometimes based on prior involvement in science activities; and (b) during extended scientific explanations about life science content, expertise in science was distributed across the family members and the museum environment so that the parents and children were both contributing to the conversation.

In this paper, we use learning sciences theory and methods to understand how families talk together about scientific topics in an interactive science center. Our inquiry helps show what everyday family talk around scientific topics sounds and looks like by studying learning as both a social and individual process. We take this approach because our goal is to better understand how families work together to craft explanations about scientific topics, as well as to learn how individual family members contribute their ideas about science into family discussions. In this way, we explore the social nature of learning in museums.

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THEORETICAL FRAMEWORK

Our analytical framework builds on situated and distributed views of learning[1] as well as on research that specifically applies socio-cultural and like theories to family learning in science museums.[2] Throughout our work, we study learning by examining the interweaving role of the individual's cognitive resources, of social interaction, and of cultural resources in knowledge construction and meaning-making of the scientific content and practices. By understanding learning as a combination of individual, social, and cultural factors, we adopt a theoretical stance on how people learn that takes into account the full social context of learning as it unfolds in real-life settings. Such a stance is typical of the way many learning scientists approach their work.

The interactions explored in this paper show family members working together to make meaning of scientific concepts in biology exhibits. To understand the learning processes occurring, we look at the social and intellectual roles that participants adopt through a line-by-line analysis of family members' *epistemic moves*. We define epistemic moves as utterances (questions and statements) that help advance the collaborative meaning-making process. Epistemic moves may include suggesting a topic for discussion, asking a clarifying question, making a statement of fact, re-voicing an idea, providing evidence for a claim, disputing someone else's claim, making a prediction, or sharing an observation or inference. Over a conversation, a series of epistemic moves by an individual can help illuminate the social and intellectual role(s) that a person holds within a group. For example, the social and intellectual roles that we found in the study included memory prompter, content expert, seeker of more information, skeptic, observer, and others.

Research Questions

How is expertise in biology (including scientific practices and knowledge) used or acknowledged within the science center during the course of a family's visit?

What are the different social and intellectual roles various family members take on during a conversation through employing a series of individual epistemic moves?

METHODS AND SUBJECTS

The team interviewed and shadowed 15 ethnically and linguistically diverse families on a trip to the science center. To be eligible for the study, the families had to be frequent science center visitors (defined by owning a yearly membership and having sent a child to at least one science center camp experience) and have at least one child between 5 and 12 years old. Ten families were Caucasian, one was South Asian, one family was biracial, and two families were Chinese American. All families were English-speaking, although 3 of the 15 families choose not to speak in English in their home. From these 15 families, we studied 44 people: 14 mothers, 8 fathers, 10 girls (9 daughters and 1 female cousin), and 12 boys (sons).

Families navigated the science center during the visit as they chose, and the research team shadowed them as they interacted with exhibit components. Data collection was open-ended and family-driven to understand how family members make sense of the scientific content they see.

After each visit, researchers created logs of each of the fifteen family's videotapes. We used the qualitative software ATLAS.ti to code for moments of rich biological explanation across family members (at least 15 utterances on the same topic). This process identified segments where family members worked together to understand biological phenomena. We analyzed the conversations using a learning science methodology to analyze verbal discourse called interaction analysis.[3] We chose this method because it allows us to consider both the cognitive and the social, interactional aspects of learning.[4] In this paper, we present two case studies that exemplify how that extended talk occurred.

FINDINGS

Within our data corpus we found that, in instances of extended and rich biological explanation, children and parents spread their expertise across each other and the museum environment (people, biological exhibits, and science center signage) in their sense making talk. The two selected case studies show families talking about dinosaurs and about insects. These cases were selected because they came from the exhibitions where our participants visited most frequently and spent the most time, and because they were typical of the way that biological explaining occurred.

Table 1. Case Study 1—Talk about Insects

	Transcript
1	Ned (N): ((looking into a honeybee hive)) That's the queen bee.
2	Laura (L): How do you know?
3	N: Cuz it has the longer behind.
4	L: ohhh.
5	L: ((turns towards her mother and raises hand)) We found the queen bee.
6	Mom (M): (from a distance) No, you didn't!
7	N: Yes, it is right there! (pointing)
8	M: where? (Mom walks up and joins Laura and Ned at the exhibit)
9	N: right there. (pointing) Cuz it has a longer behind.
10	M: I don't know.
11	M: Another question is
12	N: see?
13	M: is if the queen bug, um the queen bee doesn't do anything just lies there. But they all are moving, right?
14	L: It looks like that. (points at a bee in the hive) See that one, it's like hardly doing anything. (shakes pointer finger) Look like it says go, you gotta work harder, (Mom: yeahhhh) work harder! (leaves finger on the case)
15	M: Oh, you can see it, her like bossing 'em around.
16	L: yeah
17	M: I don't know. (Laura laughing) We have to look that up on the computer, what a queen bee looks like, how much different it is.

Talk about Insects: Coordinated Multiple Roles

The following case study describes a family's conversation as they try to understand the behavior and unique traits of a queen bee. It illustrates an episode of extended explanation and distributed expertise. The family in this case includes three members of a European-American family of five. The mother and her two children, Ned (5 years old) and Laura (7 years old), are present.

Individual Epistemic Moves

Ned made an initial claim that he had found the queen bee in the hive (line 1). Laura questioned his statement and asked how he came to know that this was the queen bee (line 2). Ned provided the evidence through pointing out that the bee he saw had a longer abdomen (line 3). Laura accepted Ned's explanation, and told her mother that "we" found the bee (line 5), thereby including herself with Ned's claim. The mother was first skeptical that the bee did have a longer abdomen (line 10) and offered a counter criterion to locating a queen bee—behavior (lines 11–13) rather than morphology. Laura accepted the mother's ideas (as she accepted Ned's) and pointed to a bee that she said was not only stationary but also directing the activities of the other bees (line 14). At the end, the mother continued her skepticism and suggested they use their computer to find a different authority on describing a queen bee.

Social and Intellectual Roles

Within the case, we see that all family members took on the role of expert by putting forth a claim with evidence (Ned with the shape of the bee, Laura with the bossing of the bees, and Mom with the offering of alternative criteria for locating the queen bee). The mother took on the role of critic or skeptic, using different direct and indirect ways to suggest the children did not have the correct idea. Laura took the role of agreeing or validating others' ideas (i.e., Ned's about the queen bee location and her mother's about the bee not moving). The museum staff also had a role in helping to distribute the talk across family members. By crafting the beehive in such a way that Ned and Laura could make observations about bee shape and behavior, the museum designers empowered these children to generate knowledge to use in the conversation. The presence of live bees in this museum learning environment helped Ned and Laura have knowledge about bees to share because they generated ideas based on what they observed.

Talk about Dinosaurs: Pursuing Multiple Educational Agendas

This case comes from a European-American family of three: a mother, father, and son (Clint, 6 years old). We selected this case study as an illustration of extended explanation and distributed expertise because of the young child's confident assertions of knowledge, and because it illustrates a pervasive pattern in our data set of a parent either helping a child read or reading exhibit labels aloud to add to the conversation.

Individual Epistemic Moves

During the conversation, Clint and his parents each made various epistemic moves that affected the direction of the discussion. Clint took several opportunities to assert his knowledge about dinosaurs. Clint's first such assertion was that a dinosaur he saw on display was a T. Rex and a meat-eater (Table 2, line 1). His mother told him that the dinosaur was an Allosaurus, and she showed him a museum label to support this identification (lines 4–6). Clint, however, was not convinced. He made the statement, "Well, I'm gonna tell

Table 2. Case Study 2—Talk about Dinosaurs

	Transcript
1	Clint (C): (walking past a large robotic model dinosaur) T. rex. Meat-eater.
2	Mom (M): Do you know the name of this one? (referring to the same dinosaur)
3	C: No.
4	M: Allosaurus? See here? You can read it. (pointing to label)
5	C: Allosaurus.
6	M: Allo-, allosaurus.
7	C: Allosaurus. Well that's not really what it is.
8	M: No, it says what it is right here. See?
9	Dad (D): What do you think it is?
10	C: Well, I'm gonna tell you something. There's all different kinds of T. rexes. All different kinds.
11	M: I think this is a different period than the T. rex. Cause you know, there's different periods. This one is from the late Jurassic.
12	C: The late Jurassic?
13	M: The late Jurassic period. So different periods, buut, this is a meat-eater like a Tyrannosaurus rex, isn't it?
14	C: Yeah.
15	M: Yeah.
16	C: And a T. rex is a Tyrannosaurus rex.
17	D: Do you know how you can tell it's a meat eater?
18	C: Yeah.
19	D: How?
20	C: How you tell, how I tell it's a meat eater is it looks kind of like that.
21	D: Like what?
22	C: That dinosaur. (points at the Allosaurus)
23	M: Can you tell by its teeth, or its head, or?
24	C: Everything.
25	M: Oh, just the shape?
26	C: Yeah.
27	D: Because it looks like a T. rex?
28	C: Because all meat-eater dinosaurs have two legs. But only some. Actually all.

you something," and continued, "there are all different kinds of T. Rexes." (line 10). Statements such as these attribute knowledge and expertise to Clint. Clint again used the pronoun "I" to personalize his knowledge in turn 20, where he started a generic assertion about how "you" tell which dinosaurs eat meat, then corrected himself to emphasize, “how *I* tell.” Clint also made claims about what “meat-eater dinosaurs” look like (lines 20–28).

The father asked Clint several times for explanations of his ideas, making space for Clint to display his knowledge (lines 9 and 17). Clint’s mother asked Clint various questions and also used the museum texts to evaluate the correctness of his replies (lines 2–8). The epistemic moves in this case study were very commonly observed of mothers and fathers throughout our sample: parents tried to help their children focus on specific examples and use the museum texts as resources.

Social and Intellectual Roles

During this family’s visit, we saw that Clint’s mother often took a traditional teacher-like role in the science center, asking questions and evaluating responses in the way that is described as a teacher-centered move.[5] She played an important science content broker role in asking Clint to apply his knowledge to new situations. We also observed the mother attempt to teach not only science but also reading, using museum texts as resources. The father had a unique role as family facilitator, making sure Clint’s voice was heard and his ideas, even if contrary to accepted canonical science, were acknowledged. Clint at various points took on different roles: expert, predictor of dinosaur behavior, and critic or skeptic of others’ epistemic authority. The skeptic or critic role was notable here because the child (Clint) was most likely to be the skeptic, not the adult (Mother). The museum too had a role in this explanation generation. Because the museum designers created half- and full-size models of multiple dinosaurs, Clint and his family were able to discuss classification and identification using clearly visible features. Also, the museum signage had information that the mother used and referred to as information from experts.

DISCUSSION

In these two cases, which exemplify other moments of extended explanation in our data set, family members shared their ideas to build collective explanations by employing a variety of epistemic moves and social and intellectual roles. One finding of our analysis was that, in all of the extended explanation segments we identified across the 15 families, expertise was distributed across adults, children, and the museum exhibition. In the case studies that we presented here, we saw that the whole family participated in building explanations when children found a topic that was familiar or in which they were interested (Clint introduced T. Rex; Ned and Laura are amateur insect collectors). Children demonstrated the ability in both of these case studies to be critical consumers of information—for example, contradicting an adult's opinion and persisting in their own ideas or, in Clint's case, also disagreeing with the authority of the museum text. These moves extended the discussion beyond the family members present because the science center resources were brought into play, both because they made the phenomena available to observe (dinosaur bodies and honeybees in our cases) and provided relevant texts that were incorporated into the family's talk.

A second finding is that family members took up intellectual and social roles to support collaborative sense-making by employing individual epistemic moves, some of which were much like the classroom roles designed by learning sciences interventions to facilitate broader participation in science.[6] For example, family members expressed critiques of each other's ideas and parents and children also shared their own ideas, often providing their reasoning or using experts as backing for the information they provided. In the cases we highlighted, the epistemic moves changed as the roles changed. In case two, Clint took on different roles such as idea suggester, critic of museum text, and skeptic of parents' ideas. Laura went from one who validates ideas to one who suggests new ideas to one who critiques ideas. The presences of these moves imply that the intellectual discourse roles used in science meaning-making, and that museum educators often design to encourage, may not be new to some children.

Understanding family conversations like the two presented is important for both museum education and for learning sciences researchers. Prior work to understand learning conversations in museums has often had a quantitative focus and/or a focus on the individual.[7] While that focus is important, work like ours adds a different dimension. We use learning sciences methods to look at the combined contributions of the individual, social, and cultural planes on collective meaning making. Understanding the nature of learning during museum visits more holistically will help educators, exhibit designers, and others design better programs because it considers a variety of factor on learning. We see in our case studies that designing environments with rich resources for observing and generating new ideas gave children a basis for their ideas and fuller participation in discussions. Granting access to phenomena for observing is a practice that can be employed in a variety of educational settings. Also, because students may already be able to develop explanations, be critical of others' (and their own) ideas, and refine ideas collaboratively, educators can use research findings like our to start with what children already know.

We envision this work informing museum design and providing museum educators a means to think about the resources that they provide to teachers and parents to support children in science learning. For example, during both family visits, more information about defining the scientific phenomena was needed (i.e., what makes a queen bee a queen bee or the difference between a T. Rex and an Allosaurus). Designers and developers can use interaction analysis to identify areas in the museum where conversations from families or school groups reveal that people want other kinds of resources to make sense of an exhibitions' content. Further investigation into social and cultural resources used by individuals could also inform design. The results of this study can help us better understand science learning in both formal and informal environments by looking for connections between family- and museum-based practices around science education.

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Notes

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Heather Toomey Zimmerman is a museum educator and doctoral student at the University of Washington in the Learning Sciences program in the College of Education. She studies how people learn science across settings with a focus on gender in science and technology disciplines. In fall 2008, she joins the faculty of Penn State University's College of Education.

Suzanne Reeve has a MS in biology education from Brigham Young University and is a doctoral candidate at the University of Washington in Learning Sciences. She studies biology learning, with a focus on health, nutrition, and multicultural influences.

Philip Bell is an associate professor of the learning sciences at the University of Washington and a Lead of the Informal Learning Strand at the LIFE Center. Recently, he co-chaired the the National Academy of Science's committee on Learning Science in Informal Environments.