Talking About Science in Museums

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ABSTRACT—***New research in museums offers a unique vantage point for observing how parent–child conversational interactions may help children learn science in everyday settings. Recent studies in this area pinpoint the role of elaborative conversation—including open-ended Wh-questions and explanatory comments—in children's understanding of scientific concepts, and more generalized effects on children's attitudes and ways of making meaning may exist as well. This review places this work in its theoretical context and discusses its potential to illuminate social mediators underlying children's learning processes and outcomes.***

KEYWORDS—*parent–child conversation; science talk; learning*

Recent years have seen an increase in questions about what children learn from visiting museums and how this learning occurs. Motivating this trend to a considerable extent is a growing recognition that museums are unique institutions of learning where people of all ages and backgrounds can expand their understanding of culture and science. Museums represent one of a range of important "informal learning environments" where children can broaden their cultural horizons and discover science, technology, engineering, and mathematics (STEM) years before they do so in school (Ash, 2002; Callanan & Jipson, 2001; Callanan & Oakes, 1992; Crowley, Callanan, Jipson, et al., 2001; Palmquist & Crowley, 2007). Moreover, museums—and other such institutions, including zoos, aquariums, and nature centers—are ubiquitous in children's lives. For example, there are more than 1,100 informal science institutions in the United States (http://pbskids.org/dragonflytv/gps/gps_localize.php) that, in addition to serving more than 12 million school children on field trips, offer other wide-ranging educational opportunities, including parent workshops, outreach programs in schools, professional development for teachers, science demonstrations, camps, and after-school programs (Association of Science-Technology Centers, 2008). Given their potential to reach large numbers of children and their families, museums figure prominently in discussions of how to enhance children's cultural understanding and scientific literacy.

Interest in learning in museums has strengthened alongside a growing movement in developmental science for researchers to become more involved with educators to address authentic practical problems. Unique partnerships have been forged, and new systematic museum research on learning is rooted in fresh cross-disciplinary and cross-institutional collaborations between university-based developmentalists within psychology and other divisions, and museum professionals with backgrounds in diverse fields, including science education, the natural sciences, anthropology, and museum education. The questions arising in museum research bridge across varied areas of developmental science from the "cognitive," such as objects-centered learning, to the "social," including motivation and identity development (see, e.g., Leinhardt, Crowley, & Knutson, 2002; Paris, 2002, for reviews). What is more, research in museums has advanced a critical effort in developmental science to move beyond the characterization of various competencies of children at different ages, to elucidate the kinds of experiences and conditions that promote children's learning processes and outcomes. Attempts to capture some of the richness of the social-communicative context in which children learn in museums are transforming definitions of learning beyond single indicators (such as facts retained or recognized) and illuminating multiple influences that bring about learning.

Research in museums presents a considerable opportunity to address serious gaps in our current understanding of how

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CHILD DEVELOPMENT PERSPECTIVES

children learn in everyday settings. To illustrate, I offer a focused review of a growing body of research on the fundamental role that parent–child conversational interactions may play in mediating children's knowledge about and approach to science. I begin the review with a description of the empirical and theoretical backdrop for research on talk in museums, and conclude it by pointing to fertile ground for further studies in these informal learning environments.

EMPIRICAL AND THEORETICAL UNDERPINNINGS

A substantial corpus of work documents clear age-related differences in almost every facet of children's scientific thinking. Older children outperform younger children in terms of the appropriateness of the hypotheses they generate, the experiments they design, and the inferences they draw based on evidence (Dunbar & Klahr, 1989; Klahr, Fay, & Dunbar, 1993; Penner & Klahr, 1996; Schauble, 1996; Zimmerman, 2000). In fact, children under the age of 10 frequently conduct scientific investigations without any explicit hypotheses at all (Penner & Klahr, 1996), and when permitted to do so, tend to end experimentation early, usually after conducting a confounded test to achieve a desired outcome (e.g., Dunbar & Klahr, 1989; Schauble, 1996). With age, children instigate a greater range of experimental tests of hypotheses that include target variables that they do not understand well (Klahr et al., 1993; Schauble, 1996). Children also less frequently jump to a conclusion after a single experiment as they get older (e.g., Gleason & Schauble, 2000). However, throughout the elementary school years, they remain conspicuously poorer than adults in designing studies that control one variable at a time (Schauble, 1996) and in making observations and recording and evaluating data (Garcia-Mila & Andersen, 2007; Gleason & Schauble, 2000; Klahr et al., 1993; Zimmerman, 2000). Nevertheless, a distillation of evidence from various training studies suggests that children's scientific skills can be improved with appropriate instruction and support, especially during hands-on experiences (e.g., Chen & Klahr, 1999).

This and more of what we have learned about children's scientific thinking at different ages stems from studies carried out in laboratory settings. The importance of this work notwithstanding, it is limited in its focus on individual children working alone to design controlled experiments, make valid inferences, generate new hypotheses, and so forth, and in its emphasis on cognitive processes "within" the children (such as metacognition) that may explain their learning and development (Crowley & Galco, 2001). Indeed, the bulk of the literature on children's scientific thinking has little to say about the experiences in children's everyday lives—including parent–child conversational interactions—that may promote the development of early scientific understanding. Museum research can inform questions about how parent–child conversations can foster children's learning of scientific information on one hand and more general skills for scientific thinking on the other. But it can also bridge to topics that studies of "scientific reasoning" do not typically address, such as whether conversations about science affect children's motivations, aspirations, interest, and productive dispositions toward science (e.g., National Research Council, 2007). It might further provide multiple insights into the implicit messages children may receive about the value of curiosity, inquiry, explanation, reason, and personal meaning-making in parent–child conversational interactions.

Over the past 10 years, in research in museums, developmental psychologists and museum educators have increasingly focused on children's conversations with their caregivers that may promote early science learning (see Leinhardt et al., 2002, for a review). This work has been guided by sociocultural theory (e.g., Berk, 2001; Gauvain, 2000; Rogoff, 1990; Vygotsky, 1978), which emphasizes that to understand learning one must focus in detail on the process of learning. In this view, children construct new understandings in everyday conversations with their parents (and other more knowledgeable members of society), in which they are "scaffolded" (Wood, Bruner, & Ross, 1976) to do and think things that they would not be able to on their own. This scaffolding is evident when parents, for example, help children to focus on what is there to learn, provide important information in response to questions, make useful analogies, tap prior knowledge, offer encouragement, and so forth, in conversations that can to a great extent influence the meaning that children make of their experiences. Put in other terms, when parents engage with their children in richly embellished and elaborated discussions of experiences as they unfold and after they occur, children are able to make sense of their experiences in ways that are likely to make them highly memorable, and what is remembered is learned (Ornstein, Haden, & Hedrick, 2004; see also Leinhardt & Knutson, 2004). Conversational interactions between parents and children in museums (and elsewhere) constitute a mechanism—a process—by which learning occurs (Fivush, Haden, & Reese, 2006; Thompson, 2006).

In addition, sociocultural theory underscores the importance of individual differences such that learning processes and outcomes can be expected to vary with the knowledge and interests children and their parents bring to an experience, and the activities and conversations they engage in during and afterward. Parents' willingness to take on the role of scaffolder, which may be driven by their knowledge but also by beliefs about their role in mediating learning, is further implicated by sociocultural approaches as predictive of learning (see Gaskins, 2008, for further discussion). Individual differences may be reflected in how much parents and children say, what they say, and how they say what they say about their experiences as they unfold and after they have occurred, as well as in what children are able to appropriate about their experiences. For example, the frequency with which parents talk about science with their children should be linked to children's science talk. Moreover, children who hear more and richer talk about science have different opportunities than those who hear less to talk about and think about science in

ways that, in turn, should enhance specific literacy-related skills (Tenenbaum & Callanan, 2008; Tenenbaum & Leaper, 2003) and perhaps foster more generally productive attitudes and approaches toward learning.

PARENT–CHILD CONVERSATIONS ABOUT SCIENCE IN MUSEUMS

Museums offer a unique vantage point from which to study parent–child conversations, making it possible for researchers to obtain a precise and dynamic record of how parents and children interact verbally (and nonverbally) during museum experiences. Although we know little about how children develop scientific literacy in everyday settings, new research in museums suggests that—consistent with sociocultural theory—the conversations children have with their parents can both reflect and change what they understand about science (e.g., Ash, 2002; Borun, Chambers, Dristas, & Johnson, 1997; Callanan & Jipson, 2001; Crowley, Callanan, Jipson, et al., 2001; Crowley & Jacobs, 2002; Palmquist & Crowley, 2007; Tenenbaum, Snow, Roach, & Kurland, 2005; Valle & Callanan, 2006). It is clear that particular types of museum exhibits can promote different kinds of conversation, and some can even thwart collaboration and learning altogether (e.g., Crowley & Callanan, 1998; Gelman, Massey, & McManus, 1991; Humphrey & Gutwill, 2005). Even so, experiences in museums can offer significant opportunities for what Leinhardt and Crowley (1998, p. 5) have called "conversational elaboration"—an expression they use to define learning in terms of the richness of the discussions parents engage in with their children during and after museum experiences.

One way that elaborative conversations may be important is that they involve the posing of questions. Children's questions reflect curiosities and interests that can be critical in initiating scientific discovery (Callanan & Jipson, 2001). They can also involve seeking needed help, such as requesting information about one step in an iterative experimental process before proceeding to the next. Parents' questions can facilitate children's understanding as well, by focusing attention on salient aspects of a problem and eliciting information from the child in an effort to diagnose what a child knows and needs to know to make sense of a science exhibit or activity (see Ornstein et al., 2004, for related arguments). Interestingly enough, observations of families in museums have shown that whereas some parents will, in a quiz-like fashion, ask narrowly focused questions that they know the answers to, others asked open-ended *Wh-* questions that elicit collaborative dialog that may extend beyond the facts, to infuse the discussion with personal meaning (Diamond, 1986; Falk & Dierking, 2002). Moreover, although most of the research in museums on parents' questions is descriptive, other work involving observations of parent–child conversations during exhibit-like activities in families' homes (e.g., a camping event; Boland, Haden, & Ornstein, 2003; Haden, Ornstein, Eckerman, & Didow, 2001; Hedrick, San Souci, Haden, & Ornstein, 2009) supports the idea that parents who ask more open-ended *Wh-* question about why things happen, how things work, and what the child thought or felt during science activities should have children who understand more and learn more about science than those whose parents do not ask these sorts of questions. In addition, caregivers' open-ended questions that follow up on children's interest may be essential in motivating sustained engagement in science-related activities in a way that may be remarkably consequential for scientific thinking (e.g., Humphrey & Gutwill, 2005; Schauble, 1996).

Conversational elaboration may also move parents and children beyond simple labeling or listing of objects or activities to explanations of them (Leinhardt & Crowley, 1998). Consistent with this view, Crowley and Callanan (1998; see also Crowley, Callanan, Jipson, et al., 2001) found that children were twice as likely to talk about what they were seeing in a museum exhibit when their parents offered explanations. Moreover, although the children rarely offered explanations themselves, in almost every case when they did, they were responding to a parent explanation. Subsequent museum work has shown that U.S. parents will sometimes offer explanations in response to children's "why?" questions, but more often, parents' explanations are spontaneous (Callanan & Jipson, 2001) and frequently involve specific information to describe, interpret, and apply prior knowledge to an unfolding experience (e.g., Callanan & Jipson, 2001; Callanan, Shrager, & Moore, 1995).

Regarding the content of elaborative talk, Crowley and Callanan (1998; Crowley, Callanan, Jipson, et al., 2001) identified three types of parental explanations in conversations with their 4- to 8-year-old children about a zoetrope—a simple animation device that in this case featured a series of frames of a running horse inside a cylinder that spins. Some explanations involve the use of causal language to link together related events ("The horse looks like it's running backward because you spun this thing the wrong way"). Others refer to unobserverable scientific principles, such as the illusion of motion ("Your mind, your eye, put together each of these little pictures and that's why it looks like it's moving"). Still others make connections between an exhibit and the children's prior knowledge and experiences ("This is how cartoons work"; all examples from Crowley, Callanan, Jipson, et al., 2001, pp. 719–720). In museums, researchers have found that any of the explanations that parents supply can be quite brief, incomplete, "explanatoids" (p. 409), falling well short of what would be deemed acceptable in a science classroom or text (Crowley & Galco, 2001). Nevertheless, even partial or fragmentary explanations can serve to scaffold children's early understanding of scientific concepts (Callanan & Jipson, 2001; Callanan & Oakes, 1992; Crowley, Callanan, Jipson, et al., 2001; Fender & Crowley, 2008) and may predict later skills (Tenenbaum et al., 2005).

Interestingly enough, in studies that generally include children aged 3–10 years, there are not apparent differences in the

number of explanations parents offer for older and younger children (Jipson & Callanan, 2003; Tenenbaum & Leaper, 2003), although parents' question asking and explaining may nonetheless depend on their perceptions of their children's skills and interests (Crowley, Callanan, Tenenbaum, & Allen, 2001; Palmquist & Crowley, 2007). In this regard, parents are more likely to believe that science is less difficult and more interesting for their sons than their daughters (Tenenbaum & Leaper, 2003), and in science tasks in homes (Tenenbaum & Leaper, 2003) and museums (Crowley, Callanan, Jipson, et al., 2001; Crowley, Callanan, Tenenbaum, et al., 2001), parents will explain more often to boys than to girls. Moreover, the frequency of parent–child elaborative conversations about science varies with cultural background and the education level and prior museum experiences of parents (e.g., Tenenbaum, Callanan, Alba-Speyer, & Sandoval, 2002). Specifically, Tenenbaum and Callanan (2008) studied families of Mexican descent living in the United States and found that in both museums and their homes, they engaged in explanatory talk equally with older and younger children. However, the subset of these parents who had completed high school offered more causal and other explanations to their children in the museum than did parents with less schooling. In addition, parents who had prior museum experience made more explanations in this setting than those who had not. Although the reasons underlying the latter two findings are debatable, they may in part result from variations in the parents' understandings of how children learn and their own role in facilitating learning (Gaskins, 2008).

What do children learn from the kinds of explanations that researchers have observed in museum settings? Causal explanations have been linked to increased conceptual understanding, especially in the domain of science (e.g., Chi, de Leeuw, Chiu, & LaVancher, 1994) and to the development and revision of children's intuitive theories of how the world works (Callanan & Jipson, 2001). Scientific principle explanations offer children domain-specific scientific information (Klahr, 2000) that children may, in turn, be able to generalize beyond the immediate learning context (Crowley & Siegler, 1999). Moreover, evidence suggests that parents' use of explanations that connect ongoing activities to children's unique interests and prior knowledge may be especially important in fostering understanding of new experiences (e.g., Tessler & Nelson, 1994). Crowley and Jacobs (2002), for example, found in a museum-like setup that 4- to 12-year-olds who heard their parents explain fossils in ways that included connecting them to previous experiences were more likely to remember the names of the fossils than children who did not receive such explanations. Similarly, Valle and Callanan (2006) found that in a homework-type activity, parents sometimes linked their 4- to 9-year-old children's past experiences to an unfamiliar science topic, and that overall, parents' efforts to point out "analogies" contributed to children's understanding. Thus, there is a good reason to suspect that parents' explanations to children in museums affect learning.

FUTURE DIRECTIONS

As this brief summary indicates, in recent years there has been an obvious increase in research aimed at describing the nature of parent–child conversations about science in museum settings. Nevertheless, there are limits to the current understanding of how parents may influence children's science learning both in and out of museums. In particular, there is a terrific opportunity in future research to take this work further by examining *what it is* about elaborative conversation (such as *Wh-* questions, explanations) that may serve to mediate learning outcomes, and to look at the processes involved in learning as they extend in time and space. Also, although a few museum researchers have begun to call attention to questions about the impact of visitor diversity on learning in museums (e.g., Gaskins, 2008; Tenenbaum & Callanan, 2008), we must coordinate efforts to obtain detailed descriptions of conversational interactions with information about how these may vary as a function of cultural background, parental education, and museum experience, and why.

One potentially fruitful approach derives from the notion that it is not just how many elaborative questions that parents ask but how children respond to them that predicts learning. For example, Ornstein et al. (2004) have argued that by posing elaborative *Wh-* questions that ask for new information about an ongoing event, a parent may call a child's attention to specific aspects of an event and determine what she or he may or may not understand. But learning may be best enhanced when this questioning results in a "joint" verbal exchange, particularly one in which the parent's *Wh-* question is followed by the child's verbal provision of the (correct) requested information. Investigations of conversations during events have emphasized the importance of joint verbal exchanges between parents and children as being more strongly related to children's later retention of event information than interactions characterized as primarily involving mother-only talk, child-only talk, or no talk (e.g., Haden et al., 2001; Hedrick et al., 2009). Indeed, Tessler and Nelson (1994) found that 3-year-olds who were observed as they visited a museum with their mothers later recalled only the objects that both the mother and the child had talked about during the experience. By looking at, for example, how parents and children discuss STEM-related concepts (e.g., mass, velocity, and building engineering) in joint conversations, and particularly focusing on the patterns of parent *Wh-* questions and child responses, we may be able to gain greater understanding about how elaborative talk facilitates science and other learning.

Another future research direction springs from the idea that the type of learning museums wish to motivate does not stop when visitors leave the museum but rather extends beyond the museum walls, becoming elaborated through multiple conversations after a museum visit, and with other experiences (Crowley & Jacobs, 2002). We need to study such "extended encoding" of experiences (Ornstein & Haden, 2001) in a developmental analysis of children's conversations with their parents about their

museum experiences in the days, weeks, and months after the visit. Theoretically, such efforts marry the information-processing framework for the flow of information within the memory system to an emphasis drawn from sociocultural perspectives to examine conversational interactions as a process by which representations are established, maintained, elaborated, and even modified over repeated discussions. Empirically, such designs can address the difficult challenge of obtaining strong evidence that learning is taking place in conversation during exhibit (and other) experiences, by revealing what the child retains. Whereas parent–child conversations in museums can offer a unique vantage point from which to observe how parents guide and support children's learning, it seems critical to explore the impact of the "linguistic milieu"—which includes parent–child conversations about events both in the present and in the past—to adequately characterize both the learning process and learning outcomes of everyday experience.

In conclusion, future research in museums has the potential to address a range of unanswered questions about what aspects of parent–child conversational interactions may be especially important for the development of children's scientific literacy, and more general attitudes and meaning-making skills. As I have argued here, answers will likely require a movement toward detailed analyses of the form and content of parent–child conversational interactions both during and after experiences that illuminate critical mechanisms that link to learning outcomes. When we think we have found these potential mediators, experimental research studies should be launched to permit casual statements, a research strategy we have found in our work to be quite promising (e.g., Boland et al., 2003; Benjamin, Haden, & Wilkerson, in press; see also Fender & Crowley, 2008). In doing so, it should be possible to shed light on the difficult but important developmental question of "What forces propel children's learning in everyday settings?" and to inform parents, educators, and policy makers how we might create more influential learning environments for children in museums and elsewhere.

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