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Developmental Science Research *with* Children's Museums, Not Just *at* Them

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In the midst of renewed calls for bringing developmental science out of the laboratory and into the real world (Golinkoff, Hirsh-Pasek, Grob, & Schlesinger, 2017), Callanan, Legare, Sobel et al. (2020) take their causal learning research to children's museums. This is a departure from most of the research on children's causal understanding in which individual children are tested in laboratory settings, isolated from the supports for learning in their everyday social worlds (Legare, Sobel, & Callanan, 2017). Museums can offer nearly perfect places for studying children's causal knowledge and behaviors, *and* caregiver-child interactions in which causal information is explored and explained. Museum exhibits for children are designed to encourage playful, hands-on exploration, based on the idea from developmental psychology that children learn through direct experience interacting with objects (Piaget, 1970). Additionally, children's engagement in museum exhibits is frequently social, and the social milieu may provide critical mechanisms for learning from hands-on activities (Vygotsky, 1978). Consequently, in museums it is possible to observe whether and how children's hands-on exploration becomes the focus of social communicative exchanges between children and their caregivers that can advance learning beyond what is available from children's direct exploration alone (Haden, 2010).

A particularly exciting aspect of *Exploration, Explanation, and Parent-Child Interaction in Museums* is that the research is not just situated *at* the children's museums. Rather, this work is grounded in a remarkable set of unique partnerships between university researchers and museum practitioners. Doing developmental psychology research in museums is a growing trend, but the nature of the working relationships forged between researchers and museum practitioners is highly variable (Callanan, 2012; Sobel & Jipson, 2016). One critical dimension along which these relationships vary is the degree to which the research might provide answers or insights that inform museum practice (Haden, Cohen, Uttal & Marcus, 2016). When decision making is shared between researchers and practitioners throughout the research process - from questions and design, to analyses and conclusions - the research is *with* the museum, and the odds for the work to affect both research outcomes and museum practice rise. So it is for Callanan, Legare, Sobel et al.'s project that addresses questions in cognitive development about whether and how social factors drive causal learning, just as it provides insights into practices museum educators and caregivers can use to foster causal learning opportunities in children's daily lives.

Callanan, Legare, Sobel et al. encourage developmental scientists to form collaborative partnerships with museums to achieve mutual goals for research and practice. These sorts of partnerships offer significant opportunities and challenges, some of which I discuss here as they related to the *Monograph* (for broader treatments, see Callanan, 2012; Sobel & Jipson, 2016).

First with regard to opportunities, understanding how children learn in museums and other informal learning environments (e.g., aquariums, homes, community centers, libraries, the internet) is an important focus for developmental science research. This is because so much learning happens in these environments, especially in the early years. It is estimated that children spend 80% of their waking hours learning in informal environments (National Research Council [NRC], 2009). Moreover, a number of recent reports (e.g., NRC, 2009; 2015) make it clear that research in informal learning environments can pay large dividends in understanding generally ways to improve learning opportunities for children, and specifically how to advance children's learning in the crucial content areas of science and engineering.

To illustrate, much of the research in museums has focused on the types of talk that are linked with children's learning through conversation during science-related experiences. The *Monograph* (see Table 6) emphasizes associations between parents' causal language (e.g., *"When you turn this gear it makes this gear spin." "How did that happen?" "What happens if you turn it the other way?"*) and children's systematic exploration and causal thinking. In our own work, parents' use of an "elaborative style," involving open-ended questions that encourage critical thinking (e.g., *Why* and *How* questions), and associations to children's prior knowledge (e.g., *How is this like your bike at home?*), is strongly related to children's subsequent remembering and transfer of learning beyond the exhibit (Benjamin, Haden & Wilkerson, 2010; Jant, Haden, Uttal & Babcock, 2014). Likewise, parents who talk more about science and engineering during exhibit experiences have children who demonstrate greater understanding and memory for the science- and engineering-related content of their experiences (e.g., Haden et al., 2014; Marcus, Haden & Uttal, 2017). Overall, a growing body of research elucidates how children's interactions with their parents in museums can support young children's informal learning.

Researcher-practitioner partnerships with museums also present opportunities for experimental research that allows for causal claims about factors that promote children's informal learning. In some studies, visitors are randomly assigned to different versions of exhibit experiences (e.g., Benjamin et al., 2010; Marcus et al., 2017). For example, in Haden et al. (2014), prior to building skyscrapers in an exhibit, one group of families engaged with Inspector Sturdy (a research assistant posing as a building inspector), who provided them with tips about building and conversation, while another group of families built in the skyscraper exhibit as usual, with no facilitation from Inspector Sturdy. In other studies, researchers provide some visitors with brief instructions about conversational strategies before visiting an exhibit (e.g., Eberbach & Crowley, 2017; Jant et al., 2014). Willard et al. (2019) randomly assigned parents to receive one of three specially designed conversation cards prior to interacting with a gears exhibit. The cards prompted parents either to encourage their children's exploration, encourage explanation, or engage with their children as they normally would. Still other work with museums involves design-based research (Barab & Squire, 2004) that puts practice at the center of the research. Design-based research with museums involves researchers and museum practitioners working together to create exhibits or programming, and then systematically

testing and iterating the design. The aim is to determine whether and how the design might best foster forms of engagement, such as families' hands-on and conversational interactions that support learning in museums.

One particular challenge with design-based research in museums is conducting quick analyses of how changes to the design of exhibits or programs affects changes in visitor behavior. One solution is what Kevin Crowley dubbed "blitz coding" of specific behaviors or patterns of engagement based on live or video recorded observations (see Callanan, 2012). Video records also provide the opportunity for systematic and often time-consuming coding of parent-child interactions in museums to identify critical learning dynamics. For example, in the *Monograph*, sequential coding was used for defining systematic exploration as 5-s intervals when children dis/connected the gears and then spun them in the succeeding 5-s interval. When the researchers further considered the timing of parents' causal talk in the sequence of children's systematic exploration, a specific mechanism by which parents' causal talk served to scaffold children's learning was revealed. Parents' engagement in causal explanatory talk at the point that children were connecting the gears anticipated whether the children would next explore the spinning function of the gears. Whereas this level of granularity of coding is beyond what museums might undertake on their own, the results can figure prominently in efforts to design practices that promote specific learning dynamics, encouraging not only particular types of talk, but also *jointness* in parent-child interactions (Haden, 2010).

Families may also behave more naturally in the museum environment than in a laboratory setting. Still, video recording in museums may make these interactions less natural, because as part of the consent process, families know they are being watched. In partnership with museums, video equipment may be built into the exhibit space and run "backstage" from a control room, so that once consent is obtained, recordings can be made fairly unobtrusively. We have used this system successfully in ongoing work with Chicago Children's Museum (Haden et al., 2016).

At Chicago Children's Museum, we also integrate platforms for research into the design of exhibits. For example, the multimedia component *Story Hub: The Mini Movie Memory Maker* was designed with research in mind. In *Story Hub*, families video record themselves engaging in conversational reflections about their experiences in the museums' exhibits. Once they have made their recordings, families have the option to email a copy of the video to themselves, and to give permission for their videos to be shared with researchers. We have used the rich unobtrusive observational database produced in *Story Hub* to understand how variations in exhibit programming can lead to more elaborative and engineering-content rich talk among families as they reflect on their exhibit experiences (Pagano, Haden, Uttal & Cohen, 2019).

Opportunities to involve families from diverse cultural groups in research may be greater at museums than in laboratory settings. Museums are making efforts to address inequity and encourage visitorship by diverse families. Likewise, the *Monograph* authors took numerous steps to achieve a sample that is ethnically and linguistically diverse. Nevertheless, the research with museums will only involve diverse families who make use of museums. We (e.g., Acosta, Solis, & Haden, 2019) have had some success working with community-based groups in neighborhoods with high populations of African American and Latinx low-income families by organizing family field trips that include free admission and transportation. Although families can come on the field trip without participating in our research, the availability of research

assistants who speak multiple languages makes diverse families' participation more likely. Assistants' language skills also allow us to observe as many families as do agree. By having one child in each family group don a baseball cap with an attached action camera, we can record multiple families' hands-on engagement and conversations at a single exhibit all at the same time.

Another challenge comes when assessing learning in museum environments. In the *Monograph,* the researchers invited families to engage in follow-up learning tasks in research room off the exhibit floor. This was important to gain information about the children's causal thinking in a fashion that was the same across the different museum sites. The tasks involved toys, and the authors likely made some compromises to limit the number of measures administered. Were it not so, the research might have been seen by families or museum-floor staff as interfering with the museum experience.

It is sometimes possible to design learning assessments that are organic to the museum environment so that these assessments may happen in exhibits. For example, to elicit children's independent reports of their learning (in contrast to the family reflections gathered in *Story Hub*) we first ask children to take a picture with a tablet computer of what they have made in the museums' *Tinkering Lab*. Then the researcher asks a number of open-ended and specific questions to elicit information about what the children have understood about and learned from tinkering. We find that most children are quite excited to show off their creations and talk about what they did in these brief interviews we call *SNAPs – Short Narratives about Projects* (Acosta et al., 2019). Moreover, children talk more about science and engineering when they have their projects with them than when they do not (Pagano et al., 2019). Therefore, the SNAPs are not only an assessment that could be put into practice by museum staff, they might even further boost learning from hands-on experiences by virtue of the opportunity for children to verbally express their learning.

Research-practice partnerships also afford opportunities for broad dissemination efforts. Publishing in academic journals is important, especially ones as widely read by developmental scientists as *Monographs* and *Child Development*. But this step is not enough when bringing developmental science into the real world. The *Monograph* authors also have an admirable record of presentations and publications aimed at practitioner audiences. Taking a wide-ranging approach to dissemination is key to ensuring that the fruits of research-practitioner partnerships *with* museums make maximum impacts *at* museums, enhancing learning opportunities for children and families.

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