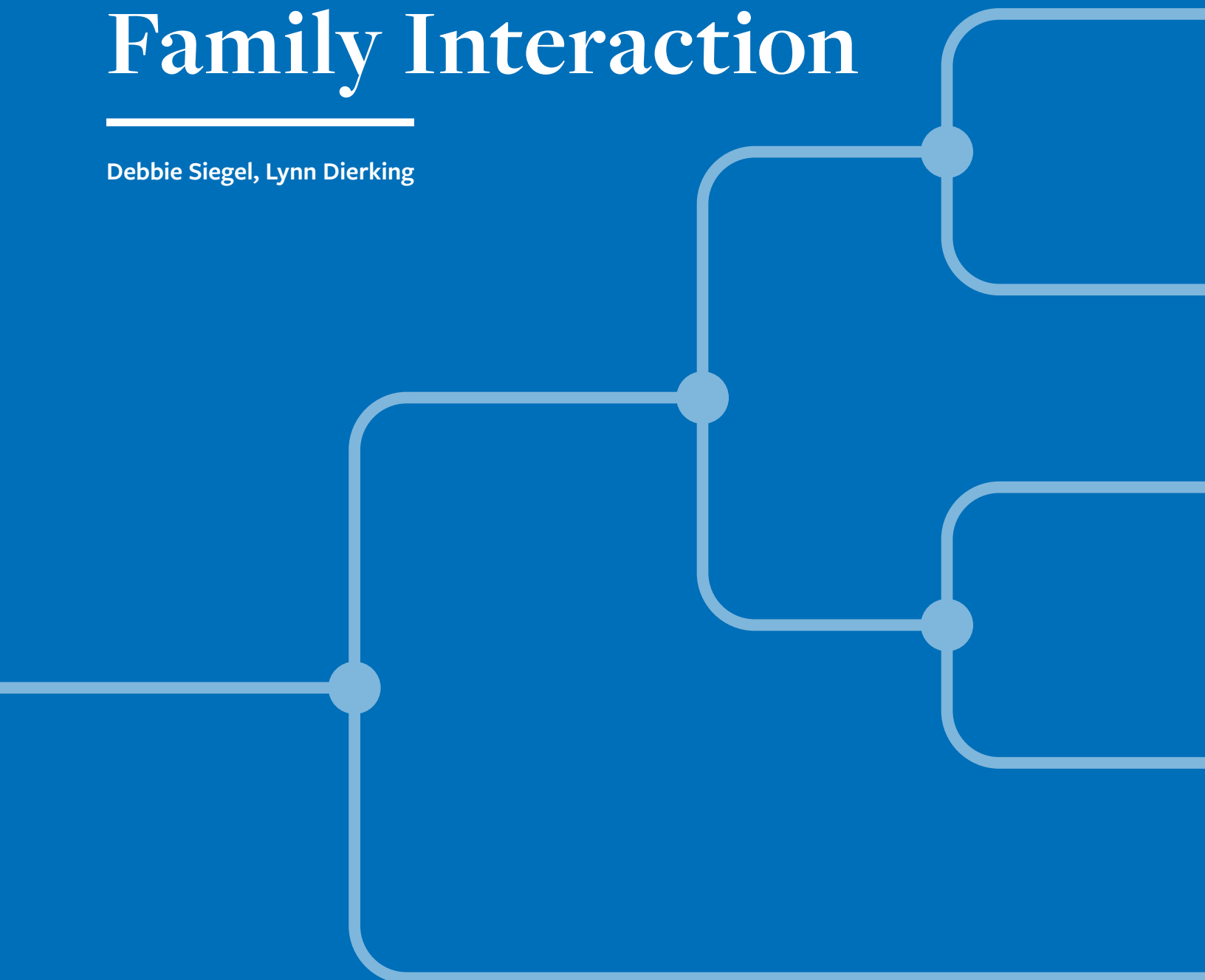


Designing Exhibitions That Engage Children by Optimizing Family Interaction

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Research demonstrates that children's early experiences in free-choice, informal learning settings like museum exhibitions can positively influence them to become lifelong learners and museumgoers by fostering their interests and curiosities.¹ However, how does one design and build exhibitions that engage children? In this article, we argue that to meaningfully engage children in exhibitions, one needs to optimize interactions between youngsters and the adults who accompany them.

In 2017, the National Science Foundation's Advancing Informal STEM Learning program awarded funding to a collaborative group of organizations to develop a comprehensive educational and media outreach initiative called *Lineage: A Cross-Platform Learning Experience Exploring the History of Life on Earth*.² This initiative was created to engage individuals and families in learning about deep time, paleontology, and evolution, as well as the present and future of life on Earth and was linked to the 2019 opening of *Deep Time*, the reimagined fossil hall of the Smithsonian's National Museum of Natural History (NMNH). Partnering organizations included Twin Cities Public Broadcasting Station (Twin Cities PBS), a nonprofit public broadcasting organization in Minneapolis-St. Paul, Minnesota, which broadcasts educational and civic programs on radio and television; NMNH in Washington, DC; and Schell Games, an education and entertainment game development company located in Pittsburgh, Pennsylvania. Rockman et al, an independent evaluation, research, and consulting firm, headquartered in Berkeley, California was the evaluator of the project. National Science Foundation (NSF) funding came with a requirement: the project had to include a research component that would help build knowledge, and contribute broadly, to the field of informal science education. We (the Institute for Learning Innovation, or ILI), a nonprofit virtual research, evaluation, and professional learning organization, were hired to conduct the research.

The project development team (Twin Cities PBS, NMNH, and Schell Games) specifically developed the entire, 31,00-square-foot exhibition in ways that would foster collaboration within family groups to support 1) children's engagement in learning scientific concepts and 2) practices related to the exhibition's key concepts. As part of the project, the team collaboratively developed a film for national broadcast and designed two exhibit activities; a hands-on exhibit activity, that would be facilitated by museum staff and a virtual reality (VR) exhibit activity as part of the *Deep Time* exhibition.³ Both the hands-on and VR exhibit activity were intentionally designed to foster family collaboration and to strengthen the paleontological research presented in the exhibition. Both elements presented similar scientific concepts and practices. Scientific concepts included, for example, that all living things have a common ancestor;

Fig. 2. The hands-on exhibit activity set-up with adult, child, and facilitator.

related living things have shared, derived characteristics; paleontologists use physical traits in fossils to show relationships; and, the tree of life is a visual representation, or tool, that depicts these relationships. Scientific practices included making observations; comparing and contrasting fossil characteristics; and hypothesizing relationships between those characteristics.

Having two different types of exhibit activities that involved similar content provided an opportunity to study how families interact with each format. Our work explored how to design for family interactions that engage children and how different exhibit approaches supported different kinds of family interactions and learning. In this article, we offer key findings from this study and their design implications.

Methods

We invited 49 children, ages eight to 12 – each accompanied by one adult caregiver – to interact with either the hands-on exhibit activity or VR exhibit activity (18 pairs participated in the first, 31 in the second; while we planned to recruit the same number of families to engage with each exhibit, scheduling took place just as the museum closed due to COVID-19, which made it impossible). It also is important to note that neither exhibit was “in situ” within the exhibition. For the purposes of the research, both were placed in a designated room off the museum floor, with only one exhibit in the room at a time. In each case, we video- and audio-taped the interactions of families with the exhibits; interviewed them when they were done; and then interviewed a subset of families two to four weeks later.

The hands-on exhibit activity, designed to be facilitated by a museum staff member, was an in-depth two-part experience. In the first part, the facilitator guides the family in making a hypothesis about which of a set of animals is most closely related. Then the facilitator introduces a board-game-like depiction of an evolutionary tree, explaining that scientists use it to show evolutionary relationships of living things through time (fig. 1). She explains how the lines represent the passage of time and the evolution of new species and how the branches indicate shared characteristics among animals and their ancestors. Families are guided in learning how to examine skulls of different animals (whale, deer, tiger, shark, seal), look for similarities among the skulls, and use the evolutionary tree to track their hypotheses and observations, ultimately uncovering which animals were more closely related (the whale and deer). Before moving on to the second part of the activity, the family is asked to make a hypothesis about whether the closest common ancestor of the whale and deer lived on land or in the ocean.

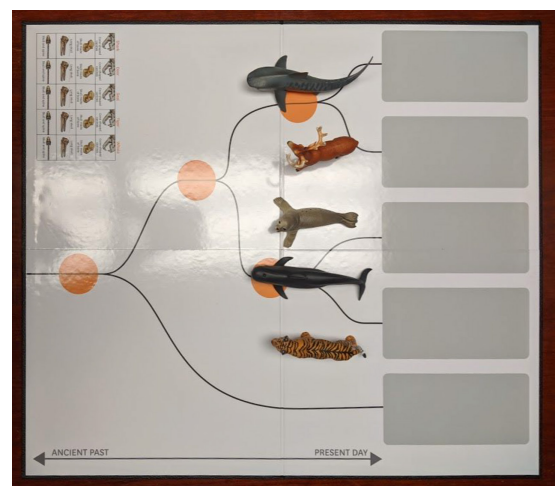


Fig. 1. The evolutionary tree being used with realistic animal figures in the first part of the hands-on exhibit activity.



The second part of the activity builds on the first, but the facilitator puts the family in charge, first describing the roles the adult and child will assume as they collaborate (the child is the assistant in the laboratory; the adult a field paleontologist). The family is tasked with finding the most recent common ancestor of the related animals (the whale and the deer) from the first part and confirming or rejecting their hypothesis. The facilitator introduces another evolutionary tree board, moveable animal cards, circle cards with different shared characteristics, and five boxes of fossil reproductions (fig. 2). The family explores the fossils to trace the evolution of whales to their most current form, noting how shared, derived traits evolved, using the “tree” to pose/answer questions about change over time, particularly how terrestrial mammals might have evolved to live in marine habitats (figs. 3 & 4).

The goal of the VR exhibit activity, which a museum staff member assisted in setting up, was to identify the closest ancestor of a mystery fossil, using scientific practices and paleontological tools. Similar to the hands-on exhibit activity, families are guided in learning about the relationship between whales and deer and how a common ancestor illustrates how some terrestrial mammals might have evolved to live in the ocean. The exhibit was designed to only have one person wear the VR



Figs. 3 & 4. Families using the evolutionary tree.



Fig. 5. The VR exhibit activity set-up with the adult on the left and child on the right.



Fig. 6. Family engaged in the VR exhibit activity.

headset; to be consistent we made the decision that only the child would wear it (figs. 5 & 6). Like the hands-on version, there were clearly defined roles within the activity's structure. In this case, the child played a paleontologist out in the field; the adult played a research assistant back in the lab. Each person saw a different screen view, with the two different screens holding unique information needed to accomplish a particular task in the activity (fig. 7). The paleontologist (child) excavated a fossil, using a brush to expose the skeleton; the research assistant (adult) pointed out features, asked questions, and ran tests in the lab (e.g., scanning an ear bone for its density) to determine fossil characteristics. Since the adult and child were not privy to the same information, they needed to examine the evidence *together* to agree on a hypothesis, moving them along in the activity (fig 8).

Key Findings

The Hands-on Exhibit Activity Resulted in Different Kinds of Learning than the VR Exhibit Activity

The tools available to families in the two exhibits varied in their physicality and their prominence. We found that this influenced adult/child interactions and the aspects of the scientific concepts/practices they remembered, both in the short term and longer term. The hands-on exhibit activity featured physical fossil reproductions that could be manipulated along with a prominent, board-game-like board of an evolutionary tree, which played a key role as an organizing tool for families as they worked through the exhibit activity. Families physically manipulated and examined fossil reproductions of different animals and described and compared shared characteristics among the fossils (see fig. 2). They were then able to use this information about shared characteristics to make hypotheses concerning

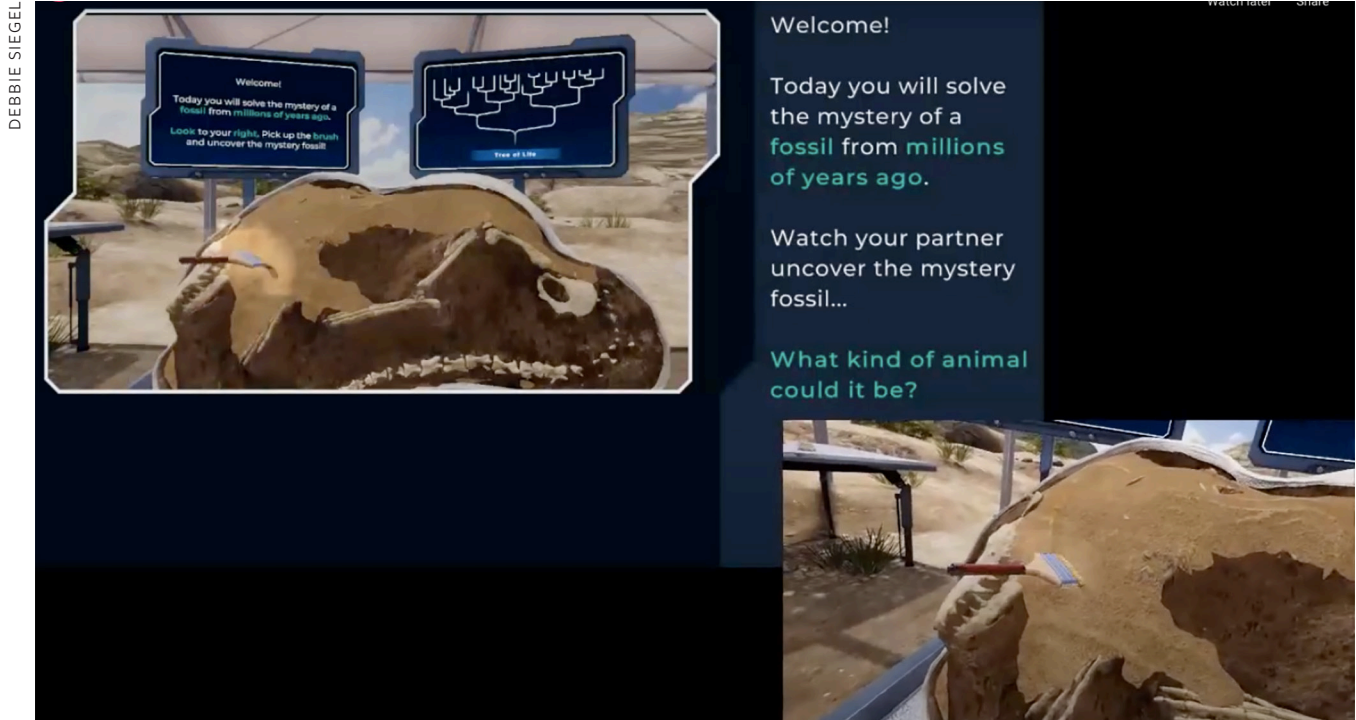


Fig. 7. The screen the adult sees with verbal prompts; the child's VR screen is embedded in the bottom right corner.

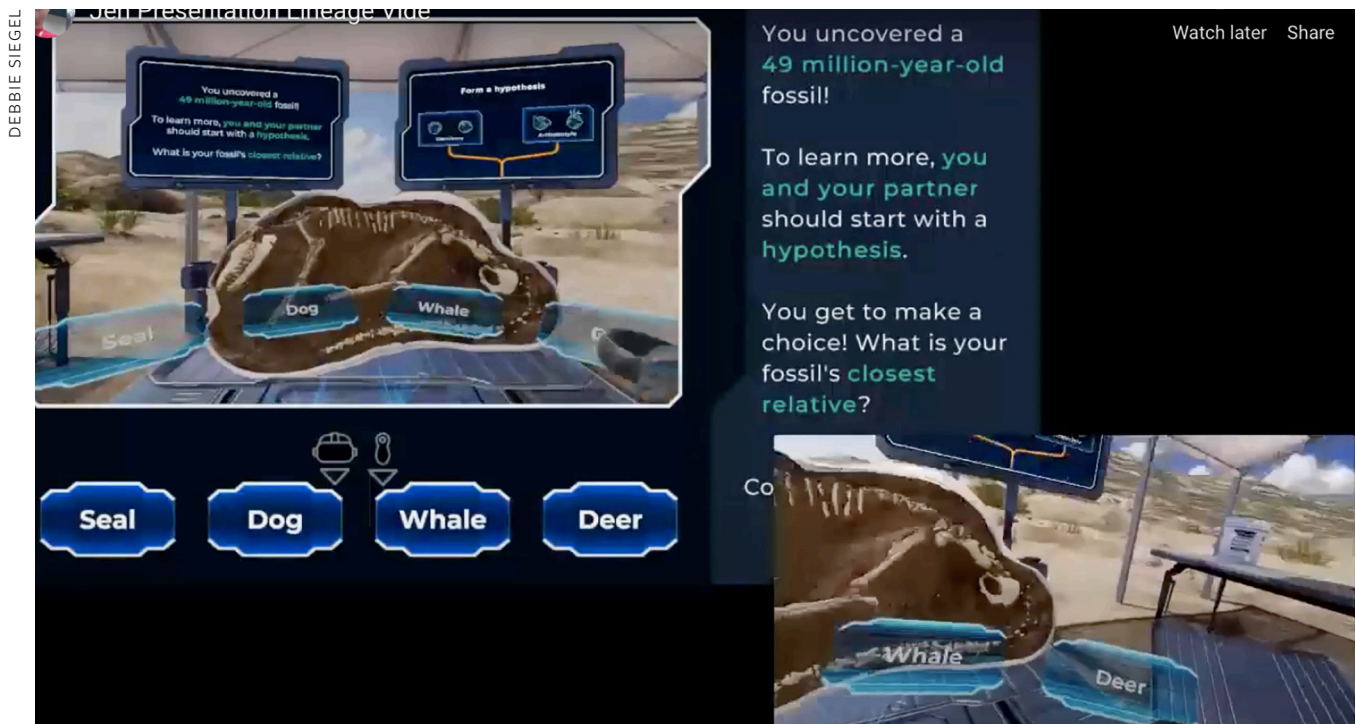


Fig. 8. The screens that the adult and child used to make a hypothesis in the VR exhibit activity.

animals' shared characteristic by physically placing pieces indicating shared characteristics and small animal cards of the animals on the evolutionary tree (see [figs. 3 & 4](#)). This important step gave families a way to organize their conceptual thinking and fostered fruitful conversations. This tool was very effective in supporting families' conceptual understanding of the activity.

The VR exhibit activity also included paleontologists' excavation and lab tools; although they were virtual, they very successfully immersed families in the work of paleontologists. Children enjoyed using these tools during virtual fieldwork and seemed to understand their purpose. The tree was also present in the VR exhibit activity. However it was less visible, and did not play a key role. Participants rarely mentioned it.

In both cases families learned, but learned different things. The hands-on exhibit activity better supported learning *scientific concepts* while the VR exhibit activity better supported families' engagement with *authentic scientific practices*.

The Structure of Adult/Child Roles in the Two Exhibit Activities Resulted in Different Collaborative Patterns

The design of both elements influenced the degree to which adults and children took on assigned roles and the extent to which they jointly attended to activity components, leading to variation in interactions. Families observed in the hands-on exhibit activity often did not take on assigned roles, which placed fewer constraints on their interactions. Some adults collaborated with the child right away, while others observed the initial activities then became more involved as the primary part of the activity began. This was evident in how the adults positioned themselves in relation to

the child and facilitator, as well as the degree to which they participated, both verbally and nonverbally. Since the adult and child interacted with the same materials, they also were able to attend to the activity and discuss their hypotheses and what they were noticing together. This ability to attend to the activity and its components together meant that families could use both verbal and nonverbal communication as they worked.

By contrast, in the VR exhibit activity, the roles were more structured within the program itself, which led to less variation in how the adult and child engaged. Also, because the adult and child did not always see the same images or directions on their screen, it was necessary for them to work collaboratively, relying on one another in order to successfully move forward in the activity. As a result, for the most part, they relied entirely on verbal communication, and were very focused on tasks and figuring out the identity of the mystery fossil.

Adults' Ability to Facilitate Learning Was a Key Factor in Both Exhibit Activities

In both exhibit activities, adults who were skilled facilitators of inquiry were more successful in helping children grasp the main idea of the activity. For example, adults in a few families in both activities were effective in supporting learning by encouraging their child to slow down and not to rush. This gave children an opportunity to reflect and think through their explanations and claims.

For example, at the hands-on exhibit activity, the father of an eight-year-old boy demonstrated how to engage in scientific inquiry, making his thinking visible. When the facilitator asked them if the common ancestor of the whale and deer lived on land or in the ocean, the child said the land. The dad seemed

unsure, then looked at his son, and said he thought it was the ocean. When the facilitator asked the child why he chose land, the child said he did not know. The dad assisted him by explaining how he made his hypothesis by looking carefully at the features of the deer. The dad then looked at the child and clarified that when he is making a hypothesis, he is making a kind of guess – thus demonstrating how to engage in scientific inquiry. Similarly, at the VR exhibit activity, the mother of a nine-year-old girl stopped her daughter a few times, instead of just going along with what she said, and asked her to explain her thinking. By walking the activity back and carefully guiding her child through it, she helped her daughter engage in scientific inquiry.

Connecting to Children’s Prior Knowledge and Shared Family Experiences Supported Learning in Both Exhibit Activities

Families at both the hands-on exhibit activity and the VR exhibit activity discussed shared experiences and understandings. We observed some adults making connections to the child’s knowledge and experiences to help guide their thinking. Making these connections drew the youngster into the conversation and helped them understand the content. For example, we observed a dad and his 10-year-old daughter at the hands-on exhibit activity. At the beginning of the activity, they had to work together to group a seal, tiger, whale, shark, and deer by shared ancestry. The dad guided her in using prior knowledge to construct her hypothesis. First, he asked if there was one thing that looked immediately different from everything else. She replied that the tiger was a different color than the others. The dad then asked if the tiger had anything in common with any other animal in the group. When she said the deer did (referring to it living on land), he pointed out that the others were sea creatures. The girl

then noted that the seal could be both a land and sea creature, and the dad agreed. The girl then thought about splitting them by sea and land, until her father asked her to describe the differences between the seal and the whale. She said they both breathe air, but the whale almost always stays under water, whereas the seal can go out of the water. He then asked what the difference is between a whale and a shark. She said that the whale breathes air, but the shark does not, discussing how each gets oxygen. Through this careful scaffolding, her dad was helping her to notice and use prior knowledge to justify her claims.

This father helped his child make further connections by drawing on shared family experiences. As they worked together to hypothesize whether the common ancestor of the whale and deer was a water or land animal, the girl hypothesized that the ancestor was on land, because she had read that whales began as land creatures and developed into sea creatures. Her dad confirmed that, and then asked her if she remembered visiting the aquarium and seeing the whale skeleton. By referring to a shared memory, he guided her to use prior knowledge and experience to reason about the present activity. She actually recalled that the whale skeleton had hip bones and her dad commented that he was surprised that she remembered. Later, during our interview with the family, the girl mentioned that her prior knowledge was helpful during the activity.

Similarly, a few families who engaged with the VR exhibit activity also referred to prior knowledge, in some cases, in making their hypotheses. For example, in a conversation between an 11-year-old girl and her mom, the girl was examining the virtual jaw and discussing whether it was more like a whale or a deer jaw. In this following excerpt, you can see how she uses her prior knowledge –

that herbivores and carnivores have different teeth – to conclude that the jaw was more like a whale jaw: “I feel like a killer whale or other whales have a jaw like that. And then deer, I think...aren’t deer herbivores?...So they would only eat plants. So, they wouldn’t need the spiky teeth.”

Implications for Design

These findings show how and why these two exhibits supported family learning and engagement. They were clearly effective in engaging families in learning both scientific content and practices in general, and particularly in the case of the VR exhibit activity, specific paleontological concepts and practices. Based on these findings, we offer some exhibit design/development implications to consider:

1. The hands-on and VR exhibit activities were structured differently and as a result supported somewhat different learning goals. As researchers who experienced both activities, we observed that the hands-on and VR exhibit activities complemented one another well. The VR exhibit activity immersed families in such a way that they experienced the practices of a field paleontologist and how they go about unraveling a mystery. As a result, and as one of the families demonstrated (a dad and his eight-year-old daughter, who experienced the VR, researched online to find out more once they got home), they were primed to learn about this in more depth and investigate the “why” behind the mystery. Thus, it might be interesting to encourage families to first experience the VR, and then engage in the hands-on exhibit activity.
2. The VR exhibit activity offered different points at which families were encouraged to discuss evidence and make hypotheses. These moments offered great opportunities for families to discuss evidence in depth and explain the reasoning behind their claims. Some adults effectively modeled how to do this with children. However, others made hypotheses without a deep discussion or talking through their evidence. To further support these critical discussions, it might be beneficial to provide further prompts that ask families to explicitly describe their reasoning and make their thinking visible. For example, after one person makes a hypothesis, a prompt as simple as “Why do you think that?” can spark further discussion. Or, since there is usually a museum staff member helping to set up the VR exhibit activity for each family, perhaps they can encourage families to do that before they begin the activity.
3. The hands-on exhibit activity provided many opportunities for reflection and deep conversation between adults and children, particularly when pairs got stuck or struggled. Observations showed that effective facilitation was often balanced in a manner that allowed families to explore, and, perhaps, even be unsuccessful at times. In other words, the best facilitation often was stepping back, letting families “struggle” a bit to foster more in-depth conversations as they worked through the activity together.

Conclusion

In this article, we argue that to design exhibits that engage children it is essential to design for the entire family in ways that optimize adult-child interactions. As these data show, parents/

significant adults are uniquely positioned in families to support children’s learning; they have shared experiences and understandings that they can reference and use to support children’s experiences within an exhibition, as well as after. Ideally, both adults and children contribute to the conversation, build on one another’s ideas, and encourage each other’s thinking. As a result, when families engage in exhibits together, they all learn together. These project findings compellingly illustrate how intentionally designing for children to collaborate with their “adults,” while offering those adults tips about how to scaffold and support the child’s experience, can be an effective way to meaningfully engage children in exhibitions. ■


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- 1 We typically allow family groups to self-define. However, in this study because of the design of the exhibits, where we conducted the research, and how (video/audio-taping interactions between adults and children), we chose to observe one adult and one child. Each child needed a caregiver’s signed permission to participate. In most cases, but not all, the adults who participated were a parent.
- 2 This material is based on work supported by the National Science Foundation under grant No. DRL- 1713142 (www.nsf.gov/awardsearch/showAward?AWD_ID=1713142).
- 3 Note that the project team often called the VR exhibit activity a “game,” however, for the research, we viewed this exhibit activity more as a virtual version of the hands-on interactive exhibit activity rather than a gamified version.




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