Understanding Parent-Child Sensemaking around Interactive Museum Exhibits

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ABSTRACT

Spark is an interactive museum exhibit designed to facilitate learning about basic concepts of electrical circuits. Visitors can make circuits on an interactive tabletop and observe a simulation of electrons flowing through the circuit. To understand parent-child sensemaking while engaged with *Spark*, we tested four different versions of the exhibit with 80 parent-child dyads at the Museum of Science and Industry in Chicago. In this paper, we present our preliminary analysis of different types of talk that families use to predict the behavior of circuits. We are in the process of creating a coding scheme to characterize the elements of our design that prompt deep, meaningful engagement between family visitors, which will help us develop principles for designing interactive exhibits that encourage rich sensemaking.

INTRODUCTION

Science centers and museums are increasingly exploring new forms of emerging interactive technologies (vom Lehn & Heath, 2005; vom Lehn, Heath & Hindmarsh, 2005; Snibbe & Raffle, 2009) and the ways in which they might be integrated into their exhibitions. While the most prevalent support for exhibit interpretation are text labels, digital interactives have become a fundamental element of most exhibitions. Interactives are often thought to enhance visitor interaction and understanding of exhibition content (Richards & Menninger, 1993; Schneider & Cheslock, 2003) as well as support different forms of co-participation among visitors. Thus, the goal is to not only have visitors engage with the interactives themselves, but for them to serve as resources for visitor conversation and exhibition interpretation. While this goal appears sound, we know very little about how engagement with interactives influences visitors' discussions about the content featured or the connections they make (or do not make) to other exhibition elements. Still, there are reasons to be optimistic that interactives can be designed to support meaningful engagement with museum exhibits.

Below we present the preliminary analyses of a pilot study intended to investigate *how (and whether) the design of interactive science exhibits can foster meaningful sensemaking among family visitors*. Towards this end, we conducted a museum study with different versions of a circuit exhibit implementing certain types of interactions using multi-touch tabletop displays, handheld devices, augmented reality techniques, and physical manipulatives. In this paper, we present our preliminary coding scheme to identify the different types of talk families use around our exhibit to make sense of circuits. We view our coding scheme as an analytic tool that we hope leads to a greater understanding of the different levels of sensemaking families enact when engaged with an interactive.

BACKGROUND

Interactives in Museums

Museum research has shown that it is possible to increase learner interest and engagement around scientific phenomena using interactive exhibits that contain novel technologies (M. Horn et al., 2012; Lyons et al., 2015; Matuk, 2016; Yoon & Wang, 2014). Technological novelty can be attractive to visitors, promote enhanced understanding of content (Allen, 2004), and engage people for extended periods of time (Sandifer, 2003). Other studies highlight the potential that technology-enhanced exhibits have in changing individuals' conceptual understandings of scientific ideas and processes of science (Falk et al., 2007; Matuk, 2016; Yoon & Wang, 2014). There are various types of innovative technologies that have been adopted and investigated in museum spaces including augmented reality techniques, multi-touch interfaces, wearable technologies, and mobile devices (for a comprehensive list of these technologies see Johnson et al., 2015; Johnson & Witchey, 2011).

Tabletop Interactives

Interactive tabletops have gained increased attention in recent years with researchers and educators interested in their use for science learning. Tabletops' capacity to allow learners to directly manipulate both virtual and physical objects (depending on the design) to solve problems enables educators and designers to create construction(v)ist learning experience for learners (Antle, Bevans, Tanenbaum, Seaborn, and Wang, 2011), a common instructional technique in the domain of science, where highly abstract concepts (like electrical circuits) are difficult to represent. Furthermore, tabletops allow multiple users to interact concurrently, meaning that they have the potential to support collaborative learning. Their ability to "support awareness of other's actions and [their] ability to support concurrent input" gives agency to every engaged learner while providing incentive for individuals to interact with each other (Rick, Marshall, and Yuill, 2011). Learners around a tabletop must negotiate their actions not only to avoid interfering with each other's intentions but also to coordinate their efforts so that they may successfully and efficiently complete tasks (Rick, Marshall, and Yuill, 2011; Dillenbourg and Evans, 2011).

Family Learning in Museums

The collaborative affordances of interactive tabletops has important implications for family learning in museums. Several studies have explored how museum exhibits can best support family learning (Dierking, Ellenbogen, & Falk, 2004; Leinhardt et al., 2003). Some museum researchers suggest "blurring the boundaries" between adults and children, advocating exhibit designs that provide opportunities for both parties to teach, learn, and bring their own knowledge and curiosity into their interpretations of exhibition content. Allowing parents and children to collaborate in this way has the potential to lead to enhanced family learning, with parents and children building on each other's explanations and gaining a stronger conceptual understanding of exhibit content (Gutwill & Allen, 2010).

Alongside the research that promotes parent-child collaboration is work that focuses on the influence of certain types of parent-child talk on children's early science understanding (Haden et al., 2014; Jant, Haden, Uttal, & Babcock, 2014). For example, "*what-if"* questions posed by parents can call children's attention to certain aspects of an exhibit while simultaneously helping parents evaluate their children's knowledge (Haden et al., 2014). Parents' open-ended questions can also be essential in motivating sustained engagement with an exhibit (Humphrey, Gutwill, & Exploratorium APE Team, 2005). In addition, in cases where knowledge is lacking and children are not able to answer, these questions may in turn lead to parental explanations, which have been documented to be effective in children's learning in museums. How children respond to their parents' questions is important to consider as children's responsiveness during a museum visit has been linked to their understanding and retention of information (Hedrick, Haden, & Ornstein, 2009).

EXHIBIT DESIGN

Spark is the result of a multi-year iterative design process through several user testing sessions and interviews to iron out the usability issues while at the same time examine engagement and learning. Using *Spark*, visitors interact with electrical circuits at two levels (see Figure 1). At one level, visitors can create a variety of circuits by wiring together circuit components (circuit-level). At another level, visitors can inspect a simulation of electrons moving through these components which conveys basic concepts of current and resistance (electron-level). To examine the design factors that can promote meaningful interaction with the exhibit, we designed four different versions of the exhibit (see Figure 2): (1) a version with no electron simulation (control version); (2) a version with an electron simulation displayed on the same screen as the circuit model (single-display version); (3) an augmented reality version with the electron simulation displayed on a separate tablet device acting as a lens that sees into the circuit (AR version); (4) and a tangible version with tangible circuit components (instead of a digital circuit simulation) coupled with the electron simulation using augmented reality (tangible version). Our goal is to investigate the design factors that enhance visitors' engagement and learning with our design.

METHODS AND DATA SOURCES

To study visitor interaction and learning, we tested four different versions of our exhibit with parent-child dyads who were visiting the Museum of Science and Industry in Chicago. For each of the four conditions in the study, we recruited 20 parent-child dyads (a total of 80 families) with children between the ages of 10 and 14 years old. We approached any group of visitors (with minors within the target age range) who passed the exhibits nearby the space where our design was set up and asked them if they were interested in participating in the study. The study sample was generally representative of the museum population, which is predominantly white (Caucasian).

We first invited participants to use the interface for their condition to complete a series of tasks that were handed to families one at a time (e.g. Figure 4). We asked participants to pretend the researchers were not in the room and to use our design as they would use any other exhibit. We also asked participants to talk out loud while interacting with the system. We designed the tasks as a way to focus families' attention to certain target concepts about electrical circuits. Each of the tasks had three parts: it opened with a statement about the circuit in question and asked families to agree or disagree with the statement (prediction); then to test their answers (exploration); and finally, to explain what they observed (explanation). Upon the completion of this phase, we interviewed the child about electricity understanding while the parent filled out a demographic questionnaire. Participants were compensated with a $10 gift certificate to the museum store. Sessions were video recorded from two different camera angles (see Figure 3). In total, the sessions took around 25 minutes to complete.

To identify different types of talk that dyads use around *Spark*, we chose to focus on the conversations that happen during the prediction part of the final task (shown in Figure 4). These conversations show dyads' sensemaking process before using the exhibit to test their answers. We chose the final task for two reasons: first, when starting this task, families have had several minutes of interaction time with the exhibit. Second, the final task was the most difficult task as it required families to construct a relatively complete understanding of current to predict the correct answer. Therefore, we saw families' conversation during the prediction part of the final task as a good source of data to characterize families' scientific conversations.

PRELIMINARY ANALYSIS AND DISCUSSION

We first transcribed and open-coded the conversations for 4 families from each condition, a total of 16 families (20% of all families in this study), and then formed a coding scheme focusing on different types of talk that families used to predict the behavior of circuits. Table 1 shows the list of codes we created to capture these mediating tools used in dyads' explanations. In this analysis, we did not account for the scientific accuracy of argumentations (correct versus incorrect claims), instead, the focus is on characterizing dyad's argument tools and resources.

We observed that some families only used a few types of talk, which in some cases were only offered by one party in the family (either the child or the parent). On the other hand, some other families had a more meaningful conversation using multiple mediating tools to come up with an answer. Parents in these families occasionally used a combination of different tools to foster a more meaningful conversation with their children; tools such as prompting questions for their children, explaining the relationships in circuit, using different types of analogies, referring to what they learned from their interaction with the exhibit in the earlier tasks, and offering or accepting answers.

The episode shown in Figure 5 illustrates an example of one dyad conversation in the AR condition. In this vignette, different types of talk happen over turns of conversations between the parent and child: the child starts her articulation with an incorrect answer but then her mother prompts a question, "*what a resistor does",* to direct child's attention to the resistor (constraining evidence), and then she uses an "analogy" to "explain" how resistors work (providing evidence). Then, the mother offers a correct answer and the child accepts the evidence provided by her mother. However, the mother immediately makes a shift in her articulation *"oh, well, I don't know"* and provokes a sequential model and incorrectly thinks that current affect the circuit point by point. The child, however, seems to disagree with her (rejecting evidence) and stays with the correct answer, which was initially offered by her mother. The mother ends the prediction task by indicating two separate opinions by each party. The dyad then start building the two circuits in the task to test their answers.

CONCLUSIONS

Interactives, in particular tabletop interactives, have been receiving increasing attention in research on museum exhibit design, but we know little about how families learn from and engage with interactive exhibits. We designed *Spark,* an interactive museum exhibit to help children learn about electricity and electrical circuits. We tested different versions of our design with parent-child dyads at a science museum to better understand the conversations families have around our design. Analyzing session videos, we have developed a preliminary coding scheme to capture the different types of talk families use around the exhibit. We view our coding scheme as an analytic tool that we hope leads to a greater understanding of the different levels of sensemaking families enact when engaged with an interactive. We hope our findings will help us better identify the elements of our design that prompt deep, meaningful engagement between visitors so that we can develop principles for designing museum interactives that support rich sensemaking.

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Figures and Tables

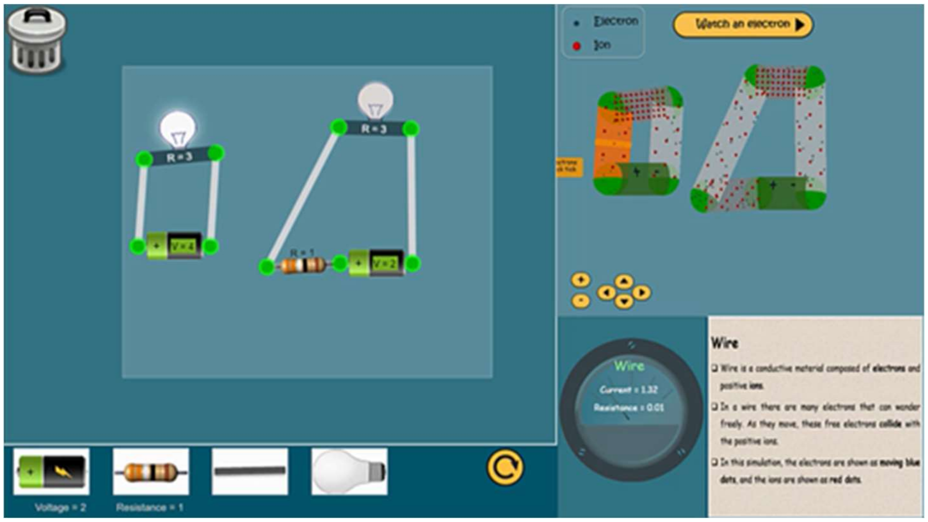

Figure 1. Snapshot of Spark system with two main components: a circuit building environment (left of screen) and an electron simulation that gets updated in real time (right of screen).

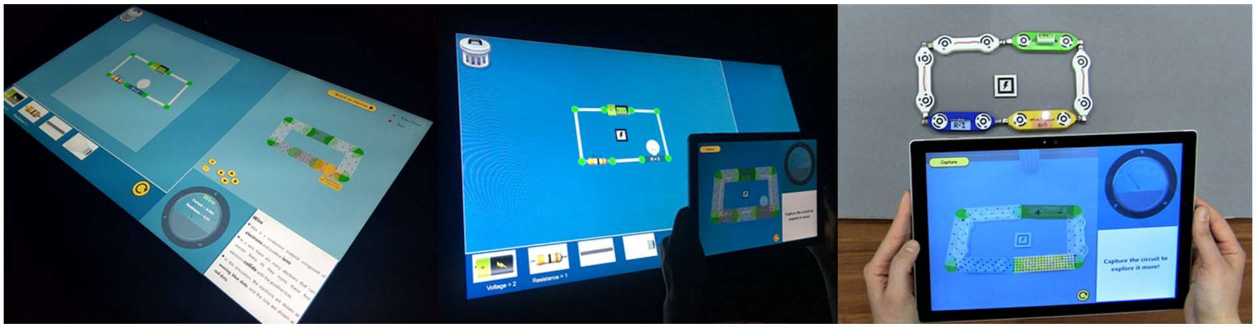

Figure 2. Three different version of our design: a single-display version (left), an AR version (middle), and a tangible version (right)

Figure 3. Snapshots of parent-child dyads using the exhibit in the single-display condition (left) and the AR condition (right)

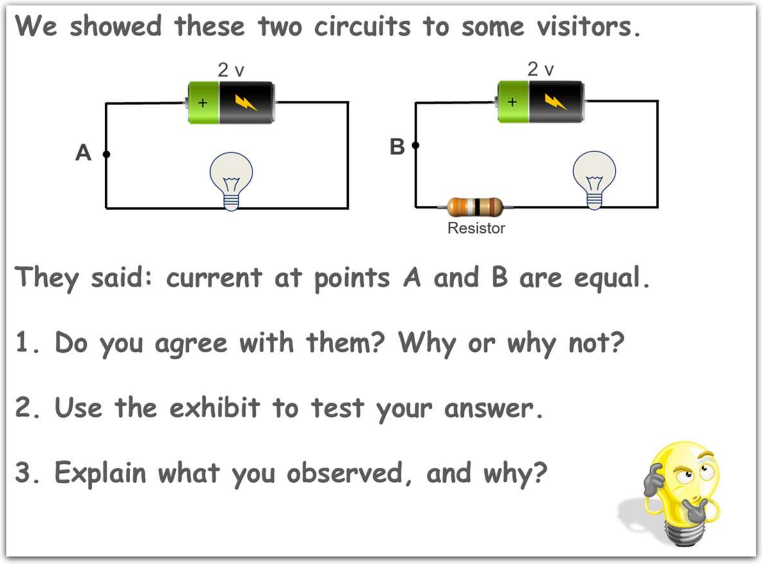

Figure 4. Final task (task 3) in the series of tasks.

Mom: ok, alright [reads the question aloud:] "we showed these two circuits to some visitors, they said currents at point A and B is equal" haa! "do you agree with them? why or why not? use the exhibit to test your answer. Explain what you observed"
Child: well, I think, umm, I agree with them.
Mom: I don't know what a resistor does [points at the resistor].
Child: I don't know .. [pause] well, I ...
Mom: the resistor means like if I am holding you [holds the child's hand] and you are pulling away from me, you are resisting me, so I think A is going to have a greater current than B.
Child: [looks at the question] Ohhhhh! Yeah! Because that has ...
Mom: oh, well, I don't know, because remember the electrons, are these electrons? [pointing at the tabletop screen] or the blue dots come out of the positive side [motions counter-clockwise from the positive side of battery] remember? [child nods head] so it doesn't have to go through the resistor. It has to go through the resistor to get to the lightbulb, but not to the point A or point B. I think they are going to be the same [looks at child, waiting for her opinion]
Child: Yeah, I don't know.
Mom: or do you think the resistor, just being in there will ...
Child: [nods head] I think it's going to slow it down.
Mom: ok, so I think equal, you think separate? [child nods yes] ok! want to clear it? [pointing at the screen] you build one [circuit] and I build one.

Figure 5. An example of one dyad conversation in the AR condition.

Table 1 .Coding scheme for types of talk in prediction part of final task

Pieces of Argumentations	Definition	Example
Providing evidence		
a. Principles	Explaining the relationships in circuits	"*Increasing the resistance reduces the current*", *"this is a resistor, it impedes the flow of electrons"*
b. Definition	Providing/referring to the definitions of circuit concepts	"*Remember, lightbulb is a resistor*"
c. Exhibit	Making connections to the prior tasks in the study	"*From the last time, it said that the current should be the same in the entire thing*"
d. Prior Knowledge	Making connections to prior knowledge or life experience.	"*So, this is Ohm's law. Haven't you yet learned it at school?*"
c. Analogy	Providing analogical connections to work with	"*Current is the speed of electrons …so like for water, how fast water flows. Knowing that, can you answer the question?"*
Constraining evidence	Directing attention to certain concepts that help solving the problem	***Child:*** *does current go this way [clockwise] or that way [counter-clockwise]?* ***Dad:*** *[…] but, the question is the resistor, how does it impact things?*
Accepting evidence	Accepting the evidence provided by the other party	"*I agree with you, let's test our theory*", "*ok, that sounds like a good answer*"
Rejecting evidence	Rejecting the evidence provided by the other party	"*but I am going to say they will be equal*"
Contrasting cases	Pointing out the differences between the two circuits in question	"*look, B has a resistor though*"
Reframing question	Framing the prediction question in a different way, e.g. from comparing currents to comparing the brightness of lightbulbs	*[the question compares the current at two points, but parent compares the brightness of lightbulbs] "Do you think this light bulb [in circuit A] will be brighter or darker than this one [in circuit B]?"*
Asking wh-questions	Asking open-ended questions that request information not previously provided	*"if you think the resistance is going to make it different, which one is going to be higher and which is going to be lower?"*
Offering answer	Making a claim or stating a solution for the question	*"I don't think it's going to be equal. I think the current at point A is going to be greater than the current at point B."*