The Unintended Effects of Interactive Objects and Labels in the Science Museum

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ABSTRACT: What effects do different setups of museum exhibits have on visitors’ conversations and interactions? The study reported here is an investigation of the role that labels and associated materials play in visitors’ conversations and interactions at a heat camera exhibit. After we introduced a label to help visitors explore the insulating properties of clothing, we found a dramatic shift in the kinds of activities and participation structures of visitors. Not only were visitors, as expected, discussing why clothing was warm, but they were doing so in a fashion more consistent with formal education than the typically more collaborative conversations seen in informal learning environments. Overall, our analyses reveal that labels and activities presented serve to frame both the activities that visitors engage in and the types of conversations that ensue and that this has deep influences on visitors’ experiences at the exhibit. © 2008 Wiley Periodicals, Inc. Sci Ed 93:161–184, 2009

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BACKGROUND

For educational researchers interested in how social interactions impact learning (e.g., Rogoff, 1990; Vygotsky, 1978; Wells, 1999; Wertsch, 1997), informal educational environments—often experienced in multigeneration groups engaging in largely self-directed activity—have proven particularly well suited for addressing these questions (Gelman, Massey, & McManus, 1991; Rogoff, Paradise, Arauz, Correa-Chavez, & Angelillo, 2003). Studies in informal educational environments lend insight into how groups structure their activities, apprenticeships, and conversations and how these contribute to learning (Borun, Chambers, & Cleghorn 1996; Dierking & Falk, 1994; Gelman et al., 1991; Rogoff et al., 2003). The museum in particular gives us a unique window onto group interactions, conversations, motivation, goals, and activities (Matusov & Rogoff, 1995; McManus, 1989; Paris, 1997). In addition, these interactions may more accurately represent the kind of short-term problem solving and learning opportunities afforded in even less structured informal learning environments, as they can bridge the largely unstructured home environment and the highly structured formal classroom (Crowley, Schunn, & Okada, 2001).

Recognizing this, researchers in museums have begun to build a body of literature on how groups in museums interact (Diamond, 1986; Ellenbogen, 2002; Hilke, 1987) and how better to structure exhibits to influence the length and nature of these interactions (Ash, 2003; Borun & Dristas, 1997; Crowley & Callanan, 1998; McManus, 1989). Much of this research concerns family interactions, which can be described as “hunter-gatherer groups who actively forage in the museum to satisfy their curiosity about topics and objects that interest them...and which museum professionals collect and study” (McManus, 1994, p. 91). The interactions of these groups at an exhibit can be understood as extensions of the cultures in which they usually exist (Duensing, 2006). And when children visit an exhibit with their parents, they typically have longer, more focused explorations of evidence than children who did not (Crowley et al., 2001). Design features can influence group interactions; for groups to engage meaningfully with exhibits, the exhibit should have multiple access points, be able to be used by many users, have multiple possible outcomes, and address content that builds on visitors’ prior knowledge (Borun & Dristas, 1997). Repeatedly, this research has stressed the role of the conversation in making meaning and scaffolding learning in museums (for a review, see Leinhardt, Crowley, & Knutson, 2002). As concluded by Crowley and Callanan (1998),

Although there are times when children learn in relative isolation, much of what they learn about their world they learn in the context of parent-child interaction. Our findings suggest that the most potent hands-on exhibits are those that recognize and support the collaborative learning and parent-child interactions.

Drawing on this research, TEAMS (Traveling Exhibits at Museums of Science) collaborative, a group of seven science museums founded to create quality traveling exhibitions suitable for small science centers, has sought to draw on and contribute to the research on parent/child conversations in the science museum and the role of exhibit design in promoting substantive conversations. Among the goals set by the collaborative are

- to further explore the influence of exhibit variables on patterns of family conversations, using existing and new TEAMS exhibitions;
- to explore how the research can be translated into a widely applicable set of design principles and concrete techniques to increase social interactions around the exhibitions (e.g., parental use of conversational strategies that enhance STEM learning); and
to develop a set of guidelines for dissemination to the field that support design of exhibits that encourage beneficial learning conversations among visitors.

This study was conducted in collaboration with researchers at Dartmouth College as part of a larger effort designed to establish a dialog between research and practice in science education. This study reports on findings from one exhibit in the study.

EXHIBIT AND MODIFICATIONS

In choosing an exhibit to study, we set out to better understand the ideas and discussions that visitors expressed about heat and temperature—a topic of significance in all the sciences and one that overlaps with ongoing laboratory-based psychology experiments being conducted in the research group. A review of the literature revealed a widespread idea among students that warm-feeling objects are inherently warmer than cold-feeling objects—believing, for example, that a coat that is warm to the touch is at a higher temperature than a tile floor that is cold to the touch (e.g., Lewis & Linn, 1994), even when both are at room temperature. To study how these ideas are constructed and discussed in informal environments, we chose to investigate conversations at an exhibit that address these ideas. In addition, we hoped to probe how we might leverage interactive objects and labels to promote conversations that guide visitors toward a deeper understanding of these ideas and explore the effects of these objects beyond the expressed conceptual gains.

To investigate these areas, we needed to ensure that our exhibit encouraged extended participation by groups. Rather than reinvent the wheel, we sought an exhibit known to align with best practices for sustained engagement that addressed heat and temperature and that we might modify if necessary. We chose an exhibit similar to one developed by the Exploratorium and described in Fostering Active Prolonged Engagement (Humphrey & Gutwill, 2005) the Heat Camera. The exhibit consists of a camera that measures infrared radiation (as opposed to the traditional camera that looks at radiation in the visual spectrum), with a typical image projected on a screen, looking like as shown in Figure 1.

Figure 1. Typical image on the heat camera.
Following the Exploratorium’s exhibit design, we included a bench, located at a position that was imaged on screen and a short “wall” behind the bench with reflective and opaque surfaces (reflective and opaque to IR but transparent to visual light). The exhibit was placed near the entrance to the museum and along a wall shared with the bathroom doors and a water fountain. Posted below the screen was a simple label that informed visitors of the relationship between gray scale and IR. In the image above, it is apparent that the cold nose and fingers are the same gray scale as the warm vest and scarf—an observation we hoped visitors would see in their own images and discuss or attempt to explain. (The reflection of IR off of a panel is also visible in top right of the image and the black glasses are blocking IR from the face.)

Although several groups described the colors they noticed (“See my black fingers?” “See your dark sweater?”) few, if any, raised ideas or explanations related to clothing and warmth. We modified the exhibit by adding an interactive table with a set of different types of gloves and a label with questions to direct visitors’ investigations. In crafting a label, we drew on research by Gutwill (2006), suggesting that a hybrid label involving questions and suggestions improved visitors’ engagement at the exhibit as compared to a label with only instructions or questions without suggestions. In addition we drew on best practices, as identified through numerous studies, in placing the label in the line of sight with the exhibit, keeping text brief, and including graphics (Stout, Talbott, & French, 1993). The label read:

Top center: “Look at the screen to see how gloves and mittens look through the eyes of a heat camera.” Left: “Notice that all of the gloves/mittens look the same before you put them on.” Right: “Try the gloves/mittens on. Which one traps your heat better? Which glove lets more of your heat leak out?”

Implicit in the questions is the idea we hoped to convey: that gloves warm hands by insulating them, not by directly heating them (Figure 2).

It was anticipated that visitors would notice that the glove that felt the warmest gave off the least amount of IR radiation (or looked the darkest/coldest on screen) and the questions on the label also directed them to interpret this in terms of “trapping” heat. Indeed, visitors did express more ideas about heat and temperature and clothing and offered correct explanations of the phenomenon—significantly more—but what leapt out at us was not the change in the content of the conversations, but the types of observations, interactions, and the structure of discussions. Below we present two representative conversations—the first from a family visiting the camera with the mittens and leading questions, the second from a family visiting the heat camera in its set up with no questions or mittens. They are representative in that the coding scheme (explained in Table 1) shows these conversations to exhibit features characteristic of the groups who visited with this setup. They are, in a way, “caricatures” of the conversations, in that they display quite vividly the distinctions between the two setups.

Family One: Label and Mittens

A visiting family of five (mother, father, two sons, and a grandmother) comes to the exhibit. The children are approximately 5 and 7 years old. The mother seats her sons side by side on the bench, the father stands back, out of the way, and the mother reads the label

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1 The exhibit designers deliberately chose to use a more vernacular than scientific use of the word “heat” in this part of the exhibit.
to her sons, walking them through the exhibit’s lesson (names in this article have been changed):

Mother: [Crouching in front of the label, reading.] So it says: “Look at the screen to see how gloves and mittens look through the eyes of the heat camera.” So, here, put this on—

Grandmother: Chris, your nose is really hot!

Mother: It says, “Notice that all of the gloves and mittens look the same on screen before you try them on. Try the- then try the gloves on. Which glove traps your heat better? Which glove lets more of your heat leak out?”

Father: Look how cold my hand is.

Mother: [Pointing to the screen while turning to face children.] So if you look here, this color is hot. And this color’s cold. So Chris, your nose is cold.

Father: That’s what I thought— yeah, cause Sara’s nose is always cold.

Mother: [Turning and standing to face father.] Just like a puppy!

Father: Yeah- just like a puppy.

Son: [Turning on bench to face brother.] Liam’s is warm- but he’s, but look, right [points to a “spot” on his younger brother’s shirt visible to the camera but not to the eye]—

Father: Liam’s face is cold.

Son: But, no—mine is black, so it’s cold.

Mother: Right.
Son: Look right here! [Again pointing to shirt.] Liam’s cold—cold right there.

Mother: [Crouching again.] So how does your—What is the color of the glove before and after you put the mitten on? Try this. Look at this, look at this before you put it on. See what color it is?

Son: [Facing forward again.] Yeah.

Mother: And then see what color it changes to after you put it on. Does it start to get lighter?

Son: Yeah, it’s black. It’s dark.

Mother: It’s dark now, but does it start to get lighter as your hand heats it up? Do you see the white spot in the middle?

Son: Yeah.

Mother: That’s where your hand is right? So, your hand is warm, so it’s making the mitten white in the middle, “cause that’s where your hand is.”

In this passage, the mother takes on the role of teacher—the children are seated quietly as she reads the label to them, and she redirects the children’s “off task” comments as they work their way through the questions and activities provided on the label. In her final comment, the mother successfully summarizes one of the main ideas we had hoped would be conveyed by the exhibit: that it is the body that makes the clothing warm, and not the clothing that is the source of thermal energy.

The grandmother makes one comment at the beginning, but quickly leaves. And the father has no role in the classroom-like routine that is being enacted—he stands back from

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<table>
<thead>
<tr>
<th>Coding Scheme</th>
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<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigation</td>
<td>Reading label</td>
<td>Visitor visibly or audibly reads label</td>
<td>“This says…”</td>
</tr>
<tr>
<td></td>
<td>Basic information</td>
<td>Visitor(s) share information related to categorizing and navigating the exhibit</td>
<td>“This is a heat camera, black is cold”</td>
</tr>
<tr>
<td>Creating and noticing data</td>
<td>Noticing data using provided objects</td>
<td>Visitor(s) point out dark/light or cold/warm objects provided at the exhibit</td>
<td>“These mittens look dark”</td>
</tr>
<tr>
<td></td>
<td>Noticing data using own objects</td>
<td>Visitors(s) point out dark/light or cold/warm objects that they provide or obtain</td>
<td>Visitor pulls out an iPod and looks at it on screen</td>
</tr>
<tr>
<td></td>
<td>Noticing data using no objects</td>
<td>Visitor(s) point out dark/light or cold/warm parts of themselves</td>
<td>“Your nose is cold!”</td>
</tr>
<tr>
<td>Creating data with provided objects</td>
<td>Visitor(s) actively manipulate objects provided at the exhibit to change the observed data</td>
<td>Visitor slides back and forth on the bench, staring at the screen</td>
<td></td>
</tr>
</tbody>
</table>

*Continued*
### TABLE 1
Continued

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating data with their own objects</td>
<td>Visitor(s) actively manipulate objects not provided at the exhibit to change the observed data</td>
<td>Visitor uses nearby water fountain to “draw” on his shirt with water</td>
<td></td>
</tr>
<tr>
<td>Creating data without tools</td>
<td>Visitor(s) actively manipulate the environment to change the observed data without using objects</td>
<td>Visitor rubs palms together or blows breath onto hands</td>
<td></td>
</tr>
<tr>
<td>Waving</td>
<td>Visitor waves at the camera/screen</td>
<td>Visitor waves at the camera/screen</td>
<td></td>
</tr>
<tr>
<td>Ranking objects</td>
<td>Visitor(s) note relative temperatures of objects</td>
<td>“This one is warmer”</td>
<td></td>
</tr>
<tr>
<td>Experimenting Question</td>
<td>Visitors ask questions about their observations or the exhibit</td>
<td>“Why is this so dark?”</td>
<td></td>
</tr>
<tr>
<td>Predicting</td>
<td>Visitor(s) express a prediction prior to looking at data on screen</td>
<td>“I think this glove will be the warmest”</td>
<td></td>
</tr>
<tr>
<td>Suggesting future experiments</td>
<td>Visitors(s) suggest other objects they would like to view, but do not retrieve these objects</td>
<td>“We should come back after going for a run”</td>
<td></td>
</tr>
<tr>
<td>Affect</td>
<td>Visitor(s) comment on not understanding and/or not enjoying the exhibit</td>
<td>“I don’t get it. This is stupid”</td>
<td></td>
</tr>
<tr>
<td>Delight</td>
<td>Visitors express enthusiasm for exhibit and/or observed phenomena</td>
<td>“Cool!”</td>
<td></td>
</tr>
</tbody>
</table>

The exhibit, his comments are frequently ignored, and when acknowledged are done so by the mother, who stands, faces him, and alters her tone, effectively signaling a frame shift (Tannen, 1993) and excluding the children from the conversation. The metamessage (e.g., Tannen, 1999) of this action is that “this comment is not part of what was going on in that conversation.”

The children, aged (approximately) 5 and 7 years, are seated, feet forward, and follow the mother’s prompts. The oldest notices interesting features (a “black spot” on younger Liam’s shirt—likely a damp spot from the snow or adjacent “bubbles” exhibit). These, too, are not part of the lesson—not features that the label asks that they notice—and therefore not attended to by the mother.

**Family Two: No Mittens or Label**

Contrast the above conversation with the following, which occurred after a family approached the heat camera and decided to go outside in the snow to see how that might change things. This family of five consists of two adults and three children, two of whom...
are similar in age to the two children in the above transcript and the oldest child approximately 11 years old. While three of the family members are outside, the mother and daughter stay inside and use friction to warm her hands. The passage below begins as the rest of the family returns:

Father: Look at my forehead!
Daughter: My cheeks!
Father: We put our hands up on the concrete wall, and our head-
Son: [Inaudible]
Mother: Man, that’s so funny! And you put your face against the brick? Oh, that’s funny. And your forehead. Oh, that’s funny. I got rid of- I got rid of Emily’s black thumbs.
Father: Look at my face- my face got-
Mother: Yeah! Well it’s cold out.
Father: You get rid of her hands?
Mother: Yeah I did, I rubbed her thumbs on my pants and then it was white- watch, watch my thumb- Look at my pants! Where it’s creating the heat. See my thumb? It’s white?
Son: Let’s go– I want to do my whole body!
Mother: [To son.] Here- come here, come here. Show your hand-
Daughter: It looks like charcoal!
Mother: Now—[rubs son’s hand against pants] see? That is so cool!
Daughter: That is so cool.
Mother: Let’s go home and eat chili- we’ll come back and be white! That is funny.

Here, in the absence of a label giving instructions on what to do and learn from the exhibit, the family has invented their own things to try—friction experiments: rubbing hands together and rubbing hands on their clothing, running out in the cold, and pressing their faces against cold objects. Although the mother has a role of directing activity, these directions and actions are in response to the things the family has done and noticed (such as cold hands and going outside). Everyone is involved in the interactions and conversations at the exhibit. Comments and actions between adults and between an adult and a child are seamlessly interwoven; they do not “break” the frame when they change conversation partners.

Although the insulating properties of clothing are not addressed and the “experiments” they try are not carefully controlled, some important ideas begin to emerge—the coldness of extremities (fingers are frequently much colder than the rest of the body), the ability to warm things by friction, that friction (unlike conduction) heats both the “rubbing” object and the “rubbed” object (such as when the mother notes that her pants are white, too).

What are we to make of these differences? What are the benefits and costs of each setup? Are there lessons to be learned for designing museum exhibits in general? We have interpreted the differences by considering the frames that visitors use when engaging with the exhibit and how these frames might be cued by artifacts (labels, benches, etc.) at the exhibit.

Previous studies have begun to note how exhibits and labels shape visitors’ expectations and activities: Rowe’s study of conversations around a rolling-cart interactive exhibit (2002, p. 33) points to how labels and adults shape “the activity around what one is ‘supposed to’ do, how one should proceed in order to live out the suggestions of the museum authority as represented by its voice embodied in the label.” This echoes Humphrey and Gutwill’s...
suggestion that instructions in exhibit labels may convey the notion that the museum is an authority and the visitor is a recipient of information. Another study investigated the effect that the type of exhibit (live animal vs. interactive) has on the kind of conversation at that exhibit (Allen, 2002), with live-animal exhibits prompting content and conceptual thinking in visitors, and conversation at hands-on exhibits focused on procedural discussion about how to use the exhibit. We suggest that the above conversations and findings from these related studies can be understood in terms of a frame suggested by the label.

FRAMING

When people encounter a new situation, they must first determine an interpretive framework that aids in understanding the activity that they are engaging in. This framing process has been intensively investigated in many fields (e.g., Bartlett, 1932/1995; Bateson, 1969/2000; Goffman, 1974; Minsky, 1975; Schank & Abelson, 1977) and taken on a variety of meanings. For our purposes, we use the term as defined in Hammer, Elby, Scherr, and Redish (2005, p. 98)

A frame is an individual’s interpretation of “What is it that’s going on here?”... Phenomenologically, it is a set of expectations an individual has about the situation in which she finds herself that affect what she notices and how she thinks to act. An individual’s or group’s framing of a situation that can have many aspects, including social (“Whom do I expect to interact with here and how?”), affective (“How do I expect to feel about it?”), epistemological (“What do I expect to use to answer questions and build new knowledge?”), and others.

Friedman (1979) has shown that the way a context is framed determines the types of information attended to and remembered. Klahr and Dunbar (1989), studying children’s unguided scientific activities, found that the frame that is instantiated shapes the types of conceptual structures invoked, as well as the activities—such as experimentation—that children engage in. Once a frame is entered into at an exhibit, then, participants in the activity have access to a script that guides not only cognitive activities, but social interactions, with specific roles for participants. Similar to findings from Klahr and Dunbar (1989) and Hammer et al. (2005), one could expect that the design of an exhibit would influence the types of frames that visitors instantiate and thereby select the types of interactions, activities, and conversations visitors display.

As we looked at the video of interactions at the heat camera in the two setups, we began to understand the setup involving mittens and labels as being framed by visitors as a traditional school-like lesson, with all of the discursive practices and participation structures that that implies. That is, upon seeing the label and questions that it poses, the group draws certain cues that help them solve the question of framing (“What is going on here?”) with the answer: a lesson. Accordingly, one adult (often the mother) functions as a teacher, the children as students, and the label as curriculum. Other adults are peripheral to the conversation—there is no easily identified “role” for them in this discourse. Topics relevant to the lesson are investigated in detail and explained relatively thoroughly. However, topics deemed “off task” are largely ignored or entertained in a frame that is clearly separate from the lesson frame (for similar findings on the role of parents as teachers, see Diamond, 1986).

In the original setup, with only a simple label describing the heat camera, visitors interpret the exhibit as a tool: a sophisticated, aesthetically intriguing thermometer. In solving the question of framing (“what is going on here?”) visitors answer: collect and create things.
to measure with this thermometer. Indeed, interactions at the heat camera were largely concerned with devising interesting patterns of heat to view—including using friction, water, bubbles, breath, and going outside to change the temperature of the body. In this scenario, all visitors have a role and share their ideas and what they are doing and noticing. A premium is placed on creative ways of manipulating temperature, and these are shared enthusiastically with and mimicked by other members of the group. This is in stark contrast with the “lesson” frame in which a premium is placed on answering the questions provided by the label; here creative ideas are rare and noticing data that is not relevant to the questions is tangential to the conversation. “What is going on here?” is a lesson about the phenomena of insulation.

Below we explore several important differences between visitor interactions and behaviors at the two setups, providing illustrative transcripts together with coded data to support this perspective on the effect of the label and mittens. First, we will address the methodology used to arrive at these findings.

**METHODOLOGY**

**Videotaping**

To capture the conversations and interactions at the exhibit, we have been videotaping, transcribing, and coding the video. Under the approval of human subjects’ review, the Montshire Museum has adopted a practice of informed consent, pioneered by the Exploratorium—that of implicit consent (Gutwill, 2003). The exhibits discussed in this article were videotaped on weekends at the museum, and on days of taping several signs were placed in the museum: one at the entrance to the museum, and others around the exhibit itself. The exhibit being taped was surrounded with stanchions so that visitors would have to pass by a large sign to enter the exhibit taping area. One researcher sat by the camera at all times to monitor activity and answer questions.

**Coding**

The researcher took notes while taping the exhibit, and used these to select both representative and intriguing clips of groups’ interactions. These clips (roughly 30–45 minutes in total) were then put on a CD and viewed individually by the entire research team. We then met to discuss and analyze our impressions of the videos, with a focus on the conversations the visitors engaged in.

Our focus on conversations stems from a sociocultural perspective, in which “individuals’ cognitive development is regarded as inherently involved with the sociocultural activities in which they engage with others in cultural practices and institutions, in a mutually constituting relationship” (Rogoff, 1990). That is, we view one of the richest forms of learning in a museum to be evident in the patterns of discourse and activities that groups engage in—such as labeling, theorizing, predicting, recognizing patterns, testing ideas, and explaining observations. These patterned activities provide a structure through which visitors construct scientific ideas and, in doing so, learn what it means to participate in scientific activities.

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2 This frame is perhaps less easily identified than the lesson frame; but it is relatively common. Give a child a pair of scissors and they may go about finding things to cut; with a new digital camera we seek out things to photograph; if you bring a microscope to a classroom, children immediately will seek out things to magnify.
In our discussions surrounding the video clips, we became interested in the role of framing in selecting the kinds of activities that groups engage in. Recognizing frames to be jointly constructed between not only the exhibit and the visitor, but also between visitors, and adopting this sociocultural perspective, our unit of analysis is the visitor group.

To support the analysis, the videotaped sessions were downloaded and segmented into clips: Each clip begins when one member of the visiting group (typically a family) enters the view of the camera and ends when the last member of that group leaves. The clips were then coded for the types of activities conducted while there—navigating the exhibit (figuring out how to use the heat camera and associated objects), creating and observing data, explanations, and expressions of affect. These were then broken down into the categories in Table 1. Codes that are shown in italics were applied but discarded for the difficulty of reliably coding (such as asking a question) or for their overwhelming presence in every group, regardless of setup (such as waving at the camera, which did not seem to be related to gathering information on the temperature of the hand but rather a ubiquitous reaction to seeing oneself on screen); these codes will not be discussed. Further details on how these categories supported our framing analysis are addressed in later sections relating to each category. In addition, the length of each group’s visit, the number of visitors in the group, and whether or not the group was returning were documented.

These codes have parallels to a coding scheme developed by Gutwill (2004) in a formative evaluation of the heat camera conducted at the Exploratorium (as part of their investigation of active prolonged engagement, or APE, exhibits), and show similarities to the categories of “learning-talk” coding scheme (Allen, 2002). However, while APE examines the degree to which social, emotional, and intellectual engagement categories are present, our investigation looks more closely at the kinds of intellectual activities the groups are engaged in and suggests particular cues that frame the activities and elicit the coded instances.

Over 100 groups (totaling 557 people and over 12 hours of video) were coded for each setup. Overlapping groups (i.e., two or more distinct groups present at the camera at the same time) were not included in this study. (We found that, by placing stanchions around the exhibit as part of our process of informed consent, groups were reluctant to enter the exhibit while another group was there. Overlapping groups were relatively rare.) Expecting that adult-only groups, child-only groups, and adult–infant groups without children have markedly different interactions from adult–child groups, we considered these visitor groups separately and found the differences to be insignificant. This result we expect to be extremely exhibit dependent, as there are exhibits in the museum that are observed to be visited more frequently by young children and others visited more frequently by adults.

The two setups yielded similar visitor patterns in terms of how many visitors came by, the size of groups, and the length of their stay (see Table 2). It should also be noted that on all of the days of taping, the museum was not crowded so pressure from other groups to hurry through the exhibit is not a factor. Those categories with an asterisk have no significant differences between groups.

### Table 2
Visitor Demographics, Length of Visit, and Differences Between These

<table>
<thead>
<tr>
<th></th>
<th>Number of Groups*</th>
<th>Average Time (s)</th>
<th>Number of Visitors*</th>
<th>Number of Adults*</th>
<th>Number of Children*</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mittens</td>
<td>100</td>
<td>83</td>
<td>287</td>
<td>127</td>
<td>160</td>
</tr>
<tr>
<td>Mittens</td>
<td>100</td>
<td>96</td>
<td>270</td>
<td>129</td>
<td>141</td>
</tr>
</tbody>
</table>

*No significant difference between groups.

Science Education
The coding was done by two coders, with preliminary coding compared to resolve discrepancies; each coder independently viewed identical clips, identified codable instances, and coded these. Discrepancies were discussed until we agreed on one code. Interrater reliability measures were made using 20% of the clips, and the measure of interrater reliability for the coding reported in this study is 87%. (More rigorous measures of interrater reliability are similarly strong. Cohen’s (1960) parameter $\kappa$ is 0.84 and Perreault and Leigh’s (1989) index of reliability is 0.93 ± 0.04.) Discrepancies in coding primarily had to do with ambiguous actions and statements by visitors: indefinite references (such as “it can’t get out”) and subtle actions (“did he deliberately rub his palms together?”). Below we report $p$ values using $t$-test or Fisher-exact tests, as appropriate.

We did not use differences in the two setups to normalize our data (by group or total number of visitors); rather we choose the group as our unit of analysis and later confirmed that our results were significant beyond what could be accounted for by normalizing. In addition, data that one would expect to be affected by the average length of stay of the groups consistently proved otherwise: though groups spent a shorter time at the exhibit in the setup without mittens or a guiding label, more activities were coded in this setup, and we concluded that normalizing for time would not be necessary nor change any results.

**FRAMING THE EXHIBIT: TOOL OR LESSON**

Significant differences between the two setups occur in five different categories of behaviors and interactions. These are creating data, noticing data, returning to the exhibit, expressions of affect (frustration, confusion, and delight), and offering explanations. These findings are detailed below and related to the manner in which visitors frame the exhibit—as a lesson (with mittens and guiding labels), or as a sophisticated thermometer (in the original, no-mittens setup). Transcripts are provided as examples of the kind of conversations surrounding the coded activities.

**Creating Data**

In the absence of a directing label, the exhibit is easily understood by most adults and even older children as being a heat camera. Once that is understood, it becomes a beautiful, pictorial thermometer—a tool for investigating their world. And visitors quickly start coming up with new ways to affect the temperature of themselves and their surroundings to see the effect on screen, with each new method being shared with the group and mimicked by others in the group. This premium on “creating” data to observe in the heat camera is evidenced in the transcript below.

A father and young daughter (about 3 or 4 years old) have been at the exhibit for a minute, the father trying what he calls “my magic healing touch” by rubbing his palms together to warm them and then warming his daughter. He then looks around and wonders how else they might warm things up to see in the camera:

**Father:** What else can we make hot? How else can we make something hot?

**Girl:** Um- rub elbows?

**Father:** [Rubs his knees/pants with hand, daughter watches and imitates.] See? It made my pants a little bit warmer—oh, here, here, another thing. Okay, look. See look. You can see on the picture where it’s whiter [pointing to pants, looking at screen] this is where my pants, my leg is pushing into my pant.
Girl: Look how it’s lighter on my leg.
Father: Huh?
Girl: It’s lighter on my pants.
Father: Right! And see how your hands are so much lighter?

This father and daughter left and returned moments later with a dampened paper towel to see what effect water would have on their temperature. Children and adults in other groups ran through with bubbles, brought in balls from other exhibits to warm up, and ran to the bathroom to splash water on themselves. They went out in the snow and returned once cooled off, they rubbed hands, clothing and their cheeks in an effort to heat them up. They licked lips, tried to place “heat handprints” on their clothing and scooted around to warm the bench.

In the presence of the label, mittens, and questions, the exhibit becomes framed as a lesson. Visitors interpret this setup as having a particular content goal: “the museum staff/exhibit designers have put this on the floor to teach me something.” No longer do visitors see their role as using the heat camera to investigate their world and create interesting visual patterns, but to work through a lesson.

In coding our data, we looked at instances of creating data—that is, deliberate actions taken to change something’s temperature (including actions that were not successful, such as trying to cool down an already cold object). Putting on a glove was not considered “creating” data, as that is where gloves usually “go”—even without a heat camera present, and it was not clear that most visitors were wearing the gloves to deliberately manipulate the temperature. This was coded as an instance of noticing data, rather than creating data, and is described in the following section. We distinguished between creating data with no objects (such as rubbing palms), with provided objects (such as the bench and mittens), and with their own objects (such as the father and daughter return with a dampened towel). Repeated instances of one action (such as rubbing palms together over and over again or trying on a mitten multiple times) are coded only once—therefore these numbers do not reflect mimicry or repetition (tokens) but the types of actions that are undertaken. Although we did not code for tokens, a brief look at a subset of our data suggests that the differences between the two setups are even more striking when considering tokens. (In addition, as will be explained below, each group’s visit was coded without reference to previous visits; i.e., if a group tries on a mitten repeatedly in one visit, we count this once, but if they return and try on the mitten again, we count that as once in each visit.) Table 3 presents the numbers from the coding, and Figure 3 shows a graph of the differences in creating data at the exhibit.

Noticing Data

Independently of the actions undertaken to influence the temperature of objects around them, visitors frequently catalog the temperatures around them: “look how cold your hands are,” “your cheeks are warm,” and “my coat is cold.” These comments are ubiquitous.

<table>
<thead>
<tr>
<th></th>
<th>Not Using Objects</th>
<th>Using Visitors’ Objects</th>
<th>Using Provided Objects</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mittens</td>
<td>107</td>
<td>18</td>
<td>16</td>
<td>141</td>
</tr>
<tr>
<td>Mittens</td>
<td>74</td>
<td>4</td>
<td>5</td>
<td>83</td>
</tr>
<tr>
<td>p value</td>
<td>.046</td>
<td>.004</td>
<td>.018</td>
<td>.005</td>
</tr>
</tbody>
</table>

Science Education
and frequently stated without analysis or explanation, but may be seen as a first step for learning how to use the heat camera and understanding the relative temperatures in their environment. What kinds of things do visitors notice when at the exhibit, and how is this influenced by the presence of a label and mittens with guiding questions?

Below is a relatively typical interaction of a family (two grandparents, a mother, and two sons—one approximately 4 years old and the other approximately 2 years old) as they approach the exhibit when the mittens and their label are not there:

Grandmother: Hi! Hi!
Mother: It takes a picture of heat, not of, not of—
Grandfather: Oh look at Grammie’s glasses! [laughs]
Mother: Yeah—it’s cause they’re cold.
Grandmother: There’s Grammie’s nose! Grammie’s nose is cold.
Mother: Look at how hot Richard’s head is [pointing to two-year-old’s head].
Grandmother: Ahh—
Mother: Look, his little brain is all lit up. And his nose is cold—isn’t that funny?
Grandmother: Yeah it is!
Mother: His brain is cookin’! [Puts her hand on his head.]
Grandfather: Is that his brain? Nah.
Mother: Yeah, ‘cause it’s a picture of heat. Look how hot the top of his head is. And look at his nose.
Grandmother: [Pointing at her hand.] Look and this finger’s cold.
Mother: Yep- my fingers are cold.
Grandfather: My fingers are warm.
Mother: Look it- look at dad’s fingers. They’re so warm.
Grandfather: They’re warm.
Grandmother: [Wiggling fingers.] As you, as you exercise them they get warmer. They change.
Grandfather: Oh my. Let’s feel these fingers. Now wait a minute, wait a minute—let’s see if we can warm them up. [Keeps his fingers on mother’s fingers.]
Mother: We did! [Laughter.]

This family has pointed out the warmth or coolness of eyeglasses, nose, heads, fingers, contrasted with other fingers and attempted to warm the fingers. Contrast this with the transcript below, where a mother and daughter (approximately 12 years old) sit down to the mittens and label.

Mother: This is an infrared camera that, um, shows body heat.
Daughter: [Picking up an orange glove.] I want to do the orange one.
[They each try on a different mitten and wait and watch.]
Mother: So this one doesn’t keep my heat in there well at all because it immediately turns white.
Daughter: This one does pretty well.
Mother: This one keeps my heat in there because it’s staying black.

The brief explanations in this passage target the idea we had hoped: that it is your hand that is hot, not the mitten, and mittens keep hands hot (or do not) by “keeping” your heat inside (or not). However, observations that were common in the original setup are now absent: no mention is made of the strikingly cold nose or warm eyes and the two launch immediately into the investigation suggested by the label.

We coded for these instances: the (somewhat passive) noticing of data (hot/cold) by visitors. We divided these into the same categories as above: noticing data without any provided objects (generally the body and clothing); noticing data using provided objects (primarily mittens, but also the bench, and the reflective surfaces—in the “No Label” scenario, the provided objects are these latter two items); and noticing data using visitors’ obtained objects (such as pulling out their wallet, taking off a watch, holding up their iPod) (see Table 4 and Figure 4).

Again, as with creating data, we interpret these differences as a reflection of how the visitors (together with the exhibit and label) are framing the experience. With the label of guiding questions present, the visitors believe they should notice the data that they are asked to notice and are less likely to comment on other interesting objects such as noses and glasses.

TABLE 4
Noticing Data at the Heat Camera in Two Setups (100 Visitor Groups)

<table>
<thead>
<tr>
<th></th>
<th>Not Using Objects</th>
<th>Using Visitors’ Objects</th>
<th>Using Provided Objects</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mittens</td>
<td>353</td>
<td>11</td>
<td>24</td>
<td>388</td>
</tr>
<tr>
<td>Mittens</td>
<td>261</td>
<td>6</td>
<td>70</td>
<td>337</td>
</tr>
<tr>
<td>( p ) value</td>
<td>.004</td>
<td>.181</td>
<td>.0001</td>
<td>.055</td>
</tr>
</tbody>
</table>

In the last transcript, in which the mother and her 12-year-old daughter work through the questions on the label, once they finish “doing” the exhibit the mother then leaves,

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having answered the questions on the label, and the daughter follows. As with the mother and sons, this pair correctly interprets the image that they see, completing the lesson and, having done so, move on.

In contrast, visitors to the heat camera in the original setup frequently returned. (Twenty-two groups of the 100 are returning—that is, we are really looking at 78 distinct groups in the original case as compared with 88 distinct groups in the mittens setup. With respect to coding, we coded all groups separately, without reference to whether they had visited before.) When they left the exhibit, they did not have the sense that they had “done” it but rather had something to gain by returning (see Table 5 and Figure 5). (One of the returning visitors in the mittens setup return because she is confused by the exhibit and trying to understand it.)

As this museum is located in a rural area, it relies on members who return frequently and finding exhibits that remain intriguing after repeat visits is crucial. The kinds of activities

**TABLE 5**

**Number of Groups and Visitors Returning to the Exhibit (100 Groups)**

<table>
<thead>
<tr>
<th></th>
<th>Number of Returning Groups</th>
<th>Number of Returning Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mittens</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Mittens</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td><em>p</em> value</td>
<td>.045</td>
<td>.008</td>
</tr>
</tbody>
</table>

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that visitors engage in when they return—especially over several visits to the museum—is one that is of particular interest. Future analysis of the heat camera and other exhibits will explore the question of how returning visitors’ activities differ from those who are there for the first time. What is surprising at a first glance is that, even though 22% of the groups visiting the exhibit (without mittens and a label) have been to the exhibit before, these groups are still averaging more use of objects and creating and noticing more data than those groups that visit the exhibit in the setup with mittens and a guiding label.3

Expressions of Affect

A further confirmation that the exhibit-as-lesson/exhibit-as-tool interpretation is a fruitful way of understanding the differences between the exhibit setups comes from looking at visitor affect at the exhibit. We coded for expressions of confusion or frustration (i.e., not when visitors convey incorrect or confusing data, but when they express that they are confused by what the exhibit is about), and for delight (laughter or expressions such as “this is cool!”).

Once a label with guiding questions is placed at the heat camera, there is something that visitors are “supposed” to notice and learn. This leads to confusion and frustration in some visitors, when they have difficulty in noticing the data that the label suggests they will see. The mittens have to be left on for several seconds before they will warm and “glow” on screen, and some mittens (the best insulators) never heat up. The mother below visited the exhibit alone and, puzzled, has returned with her husband and son (4 years old).

3 Describing differences between the groups’ initial visit and their return visit is beyond the scope of this paper; we note for the interested reader that average values in all coded categories were lower on the return visit with the exception of creating and noticing data with visitors’ objects.
The following conversation occurs with the mother seated beside her son, with the father standing behind the bench, watching.

          Mother: Come here—I’ll show you what to do. . .
Mother: [Putting mitten on her son and discussing with her husband.]
          Watch this, Ben. Here we go. It’s black.
          Father: Doesn’t get through?
Mother: [Puts another mitten on son.] This one is? [pause] Black.
Mother: Ski mitten. [Puts ski mitten on son.] And this one is—black again.
Mother: [Puts another mitten on son.] Black.
          Father: All of them are doing the same thing, they’re just a different size.
Mother: It’s retarded. It’s retarded. What kind of exhibit is this? I have no clue what to do here.

In another group of two, a 4-year-old girl, too young to read, sees the picture on the label that shows someone with both gloves on, looking into the camera. She says to her brother (6 years old) “This shows what you’re supposed to do” and the two mimic the picture. Although she does not express frustration that by doing what “you’re supposed to” there is no interesting or exciting result, her words are telling. They are further confirmation that the label sets expectations about what visitors are “supposed to do” and the visitors follow these instructions regardless of their understanding of the intent of the instructions and to the exclusion of doing what they find interesting at the exhibit. This parallels with previous work by Rowe (2005), noting that the “otherwise innocuous phrase ‘supposed to’ suggests that there is a preferred way to use the exhibit” (p. 132). Previous research suggests (Bowker, 2004; Falk & Dierking, 1992) that conversations that are less explicitly teaching oriented may lead to greater visitor engagement, corroborating the analysis here.

Eight of the visitor groups in the mittens setup expressed frustration and/or confusion, as compared to none of the groups in the no-mittens setup (Fisher exact measure = 0.005). This can be contrasted with expressions of delight. Here, as in the frustration, we coded whether or not at any time during the visit a member of the group expressed delight—counting all expressions as the same type and not counting tokens separately (i.e., did anyone in the group laugh or say “cool!”/“awesome!”/etc.). There were 57 groups in the no-mittens setup and 20 in the mittens setup that expressed delight ($p = .001$).

Explanations

The benefits to the setup that did not include mittens and a label do come at a cost; the structure provided by the labels in the mittens setup creates an investigation and leads parents to explain to their children more often than in without these objects. The given explanations are often related to insulation, as prompted by the label, but more generic explanations are given as well.

In coding for explanations, we looked for any comment that went beyond noticing that something was warm or cold, but offered a reason why (regardless of whether it was correct or incorrect). For example, a father in the no-mittens setup notices that his teeth appear warmer and informs his son that this must be “because teeth hold more heat” (in fact, the teeth are reflecting IR radiation from their surroundings). Noting that someone has cold hands and attributing this to their circulation is another explanation. We distinguished

Science Education
TABLE 6
Visitor Explanations Regarding Data at the Heat Camera

<table>
<thead>
<tr>
<th></th>
<th>Noninsulation Explanations*</th>
<th>Insulation Explanations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mittens</td>
<td>22</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>Mittens</td>
<td>20</td>
<td>26</td>
<td>46</td>
</tr>
<tr>
<td>p value</td>
<td>.46</td>
<td>.001</td>
<td>.016</td>
</tr>
</tbody>
</table>

*No significant difference between groups.

between explanations regarding insulation, as these were explicitly prompted by the labels in the mittens setup, and other explanations (see Table 6 and Figure 6).

In the mittens condition, the rate of noninsulation explanations does not change (i.e., we are not sacrificing one kind of explanation for another); here more of a premium is placed on explaining—especially striking because the families have noticed and created less data that needs explanation.

Labels

Reading labels occurred much more frequently when the mittens and guiding label were present (42 groups as opposed to 13). As a quantitative measure, this is rather empty of meaning: without the label of guiding questions present, the groups could only read one short label (“Heat Camera”), and it did not suggest any activities or prescribe a sequence of steps. Of course, reading a label is a means of interaction between the visitors and between the visitors and the exhibit, and the impact of the label on framing is clear: by suggesting a sequence of steps and an explanation for the resulting observations, visitors identify what it is they are “supposed” to do, do this, and leave.

Science Education
DISCUSSION

In claiming that visitors frame their experience as a lesson or a tool, we are, of course, speaking about general patterns in visitors’ interactions, and not the experience of all visitor groups, or even a stable pattern in any one group’s interactions. Indeed, in both setups some visitors use the bench to rest and regroup; some ignore the mittens and focus entirely on their bodies and the screen. And those who do frame the activity as a lesson, for example, often step outside of this frame, at times bringing in their own objects and holding conversations unrelated to those suggested by the label. As visitors attend to and select different features of the exhibit for their attention and conversation, different frames (and their attendant discourse and participation patterns) will emerge. In this way, the exhibit is a hybrid activity space, as discussed by Rowe (2005), where “multiple ways of knowing and discursive goals exist” (p. 124). The boy in the first transcript, by pointing out interesting features of the shirt, is making a bid for a different kind of activity than the mother is constructing, and the mother redirects, or reframes the activity—which, as Rowe notes, this defining of the situation is associated with the power dynamics of the group. The moments of hybridity, where multiple discursive goals are being posed and selected, is intriguing. If our hope is that the museum is a rehearsal space for the kinds of interactions and conversations that might happen outside of the museum, or be leveraged and serve as a touchstone for learning in more formal environments, this hybridity may facilitate the appropriation/internalization of a pattern of conversation and establish the traditional school patterns (e.g., interrogation—response—evaluation, or IRE) as but one of many ways of doing and learning science.

Similarly, we are encouraged by the activities in which visitors bring in objects and investigate these with the heat camera. Such activity recasts the objects (balls, iPods, cell phones, and snow) from their typical role (as a game, phone, or precipitation) to an object worthy of scientific investigation. We believe that this kind of activity serves to bridge the gap between “museum” science, where visitors interact with often-specialized tools and objects, and everyday activities. Again, if we understand the museum experience as a rehearsal space for scientific conversations, these objects may serve to link the museum and everyday environments and encourage scientific conversations outside of the museum’s walls and away from the museum’s specialized objects.

IMPLICATIONS FOR EXHIBIT EVALUATION

A simple first-pass at exhibit evaluation is that of time, with the expectation that visitors who spend longer at an exhibit are likely engaging more deeply with the ideas, conducting more trials or activities at the exhibit (e.g., Serrell, 1998). Our findings suggest that this is not always the case: visitors spent slightly less time at the exhibit when there was no guiding label and mittens, but engaged in far more coded activities. Evaluating the exhibit by focusing on the length of visitors’ stay would have indicated that the setup with mittens and label was preferable.

In addition, our initial goal for the exhibit was one of conceptual understanding regarding the nature of insulation: We had imagined that the label would increase visitors’ explanations and discussions regarding insulation. Had our evaluation method been targeted at assessing for these kinds of shifts in understanding we again would find the labels and mittens to be the preferable setup.

IMPLICATIONS FOR EXHIBIT DESIGN

Choosing between these exhibit designs speaks to larger decisions about what we believe to be the role of the science museum. When considering the ways in which visitors frame
exhibits, the museum is faced with questions that go beyond the scientific content of the exhibit and reveal important choices. One option is for museums to see an exhibit as a learning experience along a continuum with more formal learning contexts and perhaps a preparation for those formal learning experiences: the parents assuming the role of teacher, the children as students, more one-on-one attention, and free choice is afforded, but the structure of the conversations and interactions are similar to those in formal contexts. Here the goal of the exhibit may be to deepen visitors’ experiences with controlled, carefully structured experimentation—where labels that tightly script the use of interactives might guide visitors through this process. The labels, in this case, should provide visitors with explanations so that they leave with more scientific “content” knowledge than they entered with, demonstrated by experimentation supported by the exhibit. A second choice would be to view the exhibit as a “rehearsal space” (K. Crowley, presentation to the TEAMS Collaborative, 2004) for groups to practice having meaningful scientific conversations—where the content may be less important than practice at engaging all group members in a shared scientific activity. A key issue here is whether or not visitors create and investigate their own questions, engage the entire group, and express delight—possibly conveying that science is something this group will choose to do again. These questions also reflect a choice in what it means to “think like a scientist,” as noted by Rowe (2002, p. 33), commenting on a rolling-cart exhibit:

...if we imagine that the most important element of thinking like a scientist is to seek answer to questions about why seemingly trivial phenomena occur (why does the wheel go faster with one arrangement of weights as opposed to the other), then this object seems well suited to the task. However, if we imagine that thinking like scientists involves most importantly the control and systematic manipulation of all possible variables... then this object is not suitable.

What our analysis adds is not only that there is a connection between the choice of exhibit design and the elements of scientific thinking that one wants to promote but also intertwined in these decisions are the frames—with the attendant participant structures, activities, and discoveries—that these design and elements trigger.

The findings presented above suggest that perhaps one must choose: structured experimentation and valid explanations may come at the price of collaborative activity and excitement. Current research at the museum is investigating how we might provide the strengths of both setups: for example, “just in time” explanations and activities provided by museum explainers (volunteer staff who ask questions, suggest experiments, and provide explanations at exhibits) and optional activities (a wall of objects, including mittens, metal objects, and a square of carpet, that, together with some labels, suggest activities to try without appearing to be what you are “supposed to do” at the exhibit).

A second strand of research connected to these findings is their generalizability. The findings above should not be interpreted as implying that exhibits without labels and suggested activities encourage collaboration and exploration. Rather, there is something unique about the heat camera that it functions so effectively without any labels. In looking at visitor conversations and actions at another exhibit, the Kalliroscope (a flat disk of water with suspended particles that show turbulence in the water), visitors rarely invent their own activities and are left wondering what they are “supposed to do” (see Atkins, 2006)—in one case, a visitor asks another: “I’m not sure what I’m supposed to learn. Is it water? Is there an explanation?” The heat camera is particularly interesting for this reason—that, without any labels at all, it encourages experimentation, noticing data, and explanations. Visitors know immediately the kinds of things they are “supposed to do” and work collaboratively.
and creatively at exploring phenomena and extending their investigations. Although we can speculate on the affordances of the heat camera that makes it so accessible (it is visually arresting, it confirms many expectations but violates just enough to be intriguing, involves the whole body in experimentation, provides a visual representation of the common “feeling” of cold noses and hands, it draws on biological and physical sciences, etc.), these do not easily translate into a generic set of design principles. As with much of design-based research, the findings here are local (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003)—particular to this exhibit—but suggest important considerations for the design of exhibits in general.

The idea that this research is pointing to, then, is not that exhibits function best without directing labels but rather that there are decisions to be made in designing exhibits, and interventions that increase explanations and structure activity may come at a price. A label providing a set of questions and explanation together with interactive elements do far more than simply increase the likelihood that parents will give explanations to their children; it recasts the exhibit from its original state (which may be an open-ended intriguing tool, as in the case of the heat camera, or a confusing disk of uncertain utility, as in the case of the Kalliroscope) to a lesson, with the associated discourse patterns and participation structures that this implies. Furthermore, traditional measures for exhibit evaluation, such as pre- and posttesting and measuring time spent at the exhibit, may not capture the rich activities that have been noted here. Exhibit designers need to pay attention to not only what is said, but how. For example, are the parents redirecting “off task” comments? Are children’s ideas responded to and incorporated into the conversation? Do all of the visitors in the group have a role in the conversation? What kinds of actions are shared with others and mimicked? How does the label change the kinds of activities, actions, and comments that are “allowed”? The answers to these questions help point to the ways in which visitors are framing the exhibit and are an important evaluation tool that helps to move evaluation beyond the necessary questions of navigation and understanding toward deeper conceptions of the museum and its role in informal education.

Informal education environments, through choices in exhibit design, cue expectations in their visitors. Without an explicit attention to the choices available and the frames they set up, we may be inadvertently cuing the very frame that informal environments often try to provide an alternative to: that of formal education.

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REFERENCES


Science Education


