LET'S GIVE 'EM SOMETHING TO TALK ABOUT: HOW PARTICIPATION IN A SHARED MUSEUM EXPERIENCE CAN SEED FAMILY LEARNING CONVERSATIONS AT HOME

by

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LET'S GIVE 'EM SOMETHING TO TALK ABOUT:

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CAN SEED FAMILY LEARNING CONVERSATIONS AT HOME

Camellia Wynona Sanford, Ph.D.

Museums provide supportive spaces for families to practice talking together. Although studies have shown that families engage in rich learning conversations within museum settings, it is not yet known whether the rehearsal of such talk carries beyond the museum walls and into the home. This study was designed to test one way that a museum visit might facilitate learning conversations at home: By centering talk around everyday objects. The study took place within a travelling exhibition called *How People Make Things* and in participants' homes. Twenty-nine parent-child pairs were assessed jointly and individually before a visit to the exhibition, immediately after the visit, and two weeks later at home for evidence of changes in four areas of learning talk: content mentions, process explanations, prior references, and open-ended questions. Additional data was also collected during the families' visit to the exhibition, through parent self-reports, and during a scavenger hunt activity at home. Findings show that families' content talk immediately after the visit and two weeks later at home was significantly greater than before the visit. Families' also gave more process explanations two weeks after the visit than they had before or immediately after the museum visit. In addition, families used significantly more references to prior experiences immediately after the visit than they had before the visit. The number of open-ended questions families asked immediately after the visit decreased significantly compared to before the visit. A series of regressions looking for possible predictors of family content talk revealed that what families talked about during the museum

experience significantly predicted how families talked about content immediately after the visit. Furthermore, what families talked about immediately after the visit, as well as their everyday conversations around objects in-between visits, led to an increase in the amount of learning conversations they had together at home. An examination of changes in children's content understanding suggests that families' talk about content after their visit to the exhibition, as well as how they discussed content before their visit, resulted in a delayed payoff in which children demonstrated an increased content understanding two weeks later at home.

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1.0 INTRODUCTION

Learning happens through conversation. When parents and children talk together, they engage in a kind of collaborative sense-making, meaning that their individual conversational contributions build upon one another, resulting in a jointly constructed understanding of the world (Driver et al., 1994; Wells, 1986; Wells, 1999). This active construction of knowledge is what we, and others, define as learning (Cole & Engstrom 1993).

As designed informal environments, museums provide experiences that leverage the family as a learning system. Museums mediate opportunities for families to talk and interact around a set of ideas that help parents and children construct ways of thinking about the world together (Ash, 2003; Crowley, Schunn, & Okada, 2001; Schauble & Bartlett, 1997). In this way, museums can be thought of as schools for talk, where families learn how to talk to one another about specific topics through their encounters with rich exhibit activities.

While compelling evidence exists demonstrating that museums provide a scaffolded setting for families to build knowledge and rehearse ways of talking, it is not clear whether the learning conversations families have during their museum experience change how they talk at home. Although visitors have anecdotally reported talking about their visit with others (Falk & Dierking, 1990; Stevenson, 1991) or engaging in complementary subsequent activities like reading books on the exhibit topic (Medved, 1998; Tully & Lucas, 1991), there have been few

systematic studies of the direct effect of a museum experience on family's understanding of and conversations about exhibit content at home (Ellenbogen, 2003; Tenenbaum & Callanan, 2008).

Therefore, the purpose of this study is to address whether participation in a shared museum experience facilitates the transfer of ideas and ways of talking across contexts to the home. In other words, does what and how families talk about ideas during their museum visit increase the amount of learning conversations they engage in at home and support the development of children's conceptual understanding? Initially, a distributed cognition perspective, which considers the social, material, and environmental resources available to the learner, was used to explore these questions (Lave, 1988). Yet the idea of transfer across environments is problematic using a distributed cognition model (Vosniadou, 2007). Therefore, we created a more flexible model, the Transferrable Resources framework, that could account for mobile social resources like conversation and material resources like everyday objects. We hypothesize that transferrable social and material resources help facilitate learning as families move from setting to setting, in this case, from museums to their homes.

1.1 MUSEUMS FOSTER RESOURCES FOR FAMILY LEARNING

In terms of their ability to enhance family's social resources, museums are uniquely positioned to help support parents and children in learning how to talk to each other. Museum exhibitions are designed to communicate complex concepts, encourage collaboration among visitors, and facilitate engagement with a variety of objects and interactives (Borun, Chambers, & Cleghorn, 1996; Blud, 1990; Crowley & Callanan, 1998). For families, museum exhibitions are mediated rehearsal spaces for them to explore how, in addition to what, they learn together (Palmquist &

Crowley, 2007). As families rehearse how to do and talk about exhibits together, they become "museum literate", increasingly competent at meaning-making around objects (Stapp, 1984). Such families are able to have productive learning conversations where they ask each other questions about museum activities, provide explanations to describe the phenomena being viewed, and connect exhibit objects and ideas to prior shared experiences (Leinhardt & Knutson, 2004). Participation in this type of talk during a museum experience is considered to be productive because it is highly correlated with increased visitor understanding of an exhibition's content (Borun, Cleghorn, & Chambers, 1996; Leinhardt & Knutson, 2004). However, it has yet to be seen whether the rehearsal of these conversations continues once families leave the scaffolding of the museum environment, a space that has been thoughtfully designed to promote learning, and return home.

Museums also provide families with access to material resources such as extraordinary objects that they cannot see anywhere else. Collections-based museums use this approach to display one-of-a-kind or unusual artifacts that are meant to provoke visitors' curiosity (Gurian, 1999). Yet places like children's museums and science centers are audience focused, rather than collections-based (Mayfield, 2005). Science centers use ordinary objects to demonstrate unfamiliar principles, while children's museums present ordinary objects in a way that lets visitors do something extraordinary with them (Wellington, 1990). This ordinary object approach not only mediates rich experiences around objects that are familiar to families in the museum, it also has potential to activate parents to engage in powerful learning conversations with their children when they come across similar objects at home. Since encounters with objects or activities similar to those seen during a prior event seem to cue people to remember and talk about that event (Holtzblatt & Jones, 1993; Sehulster, 1989), we might expect families,

who come across objects or activities in their daily lives that are similar to those seen in the museum, to recall and rehearse what they had seen, done, and talked about at home (Medved, 1998).

1.2 PURPOSE OF THE STUDY

To explore the idea that familiar material resources can encourage the transfer of family conversations from one learning environment to the next, this study focused on a traveling museum exhibition about manufacturing called, *How People Make Things (HPMT).* The exhibition was an ideal test case to examine how a museum experience can seed family conversations at home using the "ordinary object" approach because both the topic of the exhibition and the designed activities within the experience center around how everyday objects are made.

We hypothesized that by presenting ordinary objects in a process context, the exhibition would facilitate the development of families' process understanding by providing a mediated experience where families could co-construct knowledge through conversation. Furthermore, encounters with everyday objects at home would give families additional opportunities to reinforce their understanding of manufacturing content, and engage in productive learning conversations similar to those practiced in the museum.

1.2.1 Research Questions

As stated before, the goal of the current study was to explore how a shared museum experience affected how and what families talked about at home. Specifically, three questions guided this research:

1.) Does the learning talk families engage in during a shared museum visit increase the amount of learning conversations families have at home?

2.) Does the learning talk families engage in during a shared museum visit support an increase in children's understanding of the processes used to make everyday objects once they return home?

3.) Under what circumstances do learning conversations about everyday objects occur at home?

2.0 REVIEW OF THE LITERATURE

2.1 DEVELOPING A NEW MODEL OF FAMILY LEARNING

2.1.1 A Distributed Cognition Perspective

In thinking about the nature of learning, ideas are not the sole property of one individual. Instead, learners come across a variety of social, material, and environmental resources in their daily lives that help them make sense of the world around them (see Figure 1). From this distributed cognition perspective, learning is mediated through relationships between people, objects, and the environment, and learners draw upon these resources in order to make meaning (Greeno, 1989; Lave, 1988; Moll, Tapia, & Whitmore, 1993).

Applying this model to families, we find that parents and children learn together by acting as each other's social resources, sharing knowledge about a particular topic through the conversations that they have with one another (Jipson & Gelman, 2007; Snow & Kurland, 1996; Waxman & Medin, 2007). Families also interpret phenomena based upon the objects they engage with and the physical environments they interact within (Eberbach & Crowley, 2005; Hoff-Ginsberg, 1991; Hohenstein & Tran, 2007; Paris, 2002). However, the distributed cognition framework is limited because it focuses on learners engaging with one environment at a time. Families operate as mobile learning systems, talking and interacting with one another in multiple contexts such as the dinner table, in the car, or at museums to develop a shared understanding of

the world around them (Ellenbogen, 2003). Therefore, the distributed cognition model must be expanded upon to account for the dynamic nature of family learning.

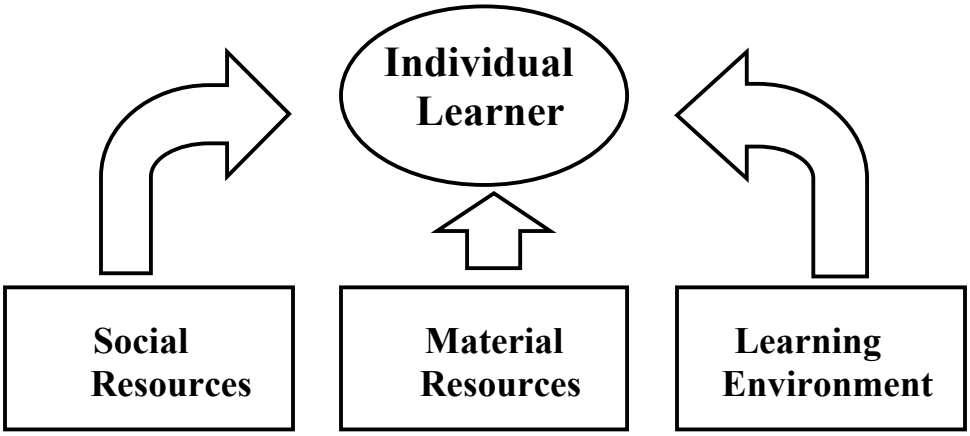

Figure 1. Learning in a Distributed Cognition Framework

The difficulty in using the distributed cognition model to account for family learning is the notion that learning can transfer across contexts. For proponents of distributed cognition, the idea that learning transfers is problematic because knowledge is intimately tied to the people and environments in which it was originally constructed (Lave, 1988; Vosniadou, 2007). When a learner enters a new environment, he or she encounters a whole new set of social and material resources with which to build understanding.

2.1.2 Constructing the Transferrable Resources Framework

Yet there is some evidence to suggest that the transfer of ideas between settings is actually more likely to occur if some of the resources from the new environment overlap with a previously explored learning environment, linking the two contexts together (Engle, 2006). Under this assumption, family groups are well-positioned to transfer ways of talking and learning about

ideas between settings because they are a social resource that moves across place. If material resources from the previously-explored environment also appear in the new environment, families may be able to use them to build deeper content understanding because they have already practiced talking about those objects in a previous learning context (Sehulster, 1989). We call this the Transferrable Resources framework, and believe it better explains the dynamics of family learning by taking into account the multiple resources and spaces families utilize when learning about a topic together (see Figure 2).

The main premise of this model is that families use familiar objects, activities, and ways of talking to guide their conversations and contribute to their content understanding in novel learning environments. These familiar resources are considered to be transferrable because they are part of a prior shared family experience, but can be found and referenced in other settings. For example, a family that purchases a glass necklace that they watched being made in-person, may later recall the necklace while viewing a television program on glass-blowing, and use it as a material resource to talk about the differences between how the glassmaker created the jewelry they own and how the glass objects on the show are made. Non-transferrable resources are objects, activities, and ways of talking that are present only in prior learning contexts. For example, while a park ranger may provide a family with rich dialogue about the diet of banana slugs, the family is unlikely to have access to material resources like a live banana slug or social resources like the docent and his expertise once they return home. Although the family may still encounter new social and material resources that they can use to help them understand information in their present learning environment, the Transferrable Resources framework is more focused on resources that can be used across multiple settings.

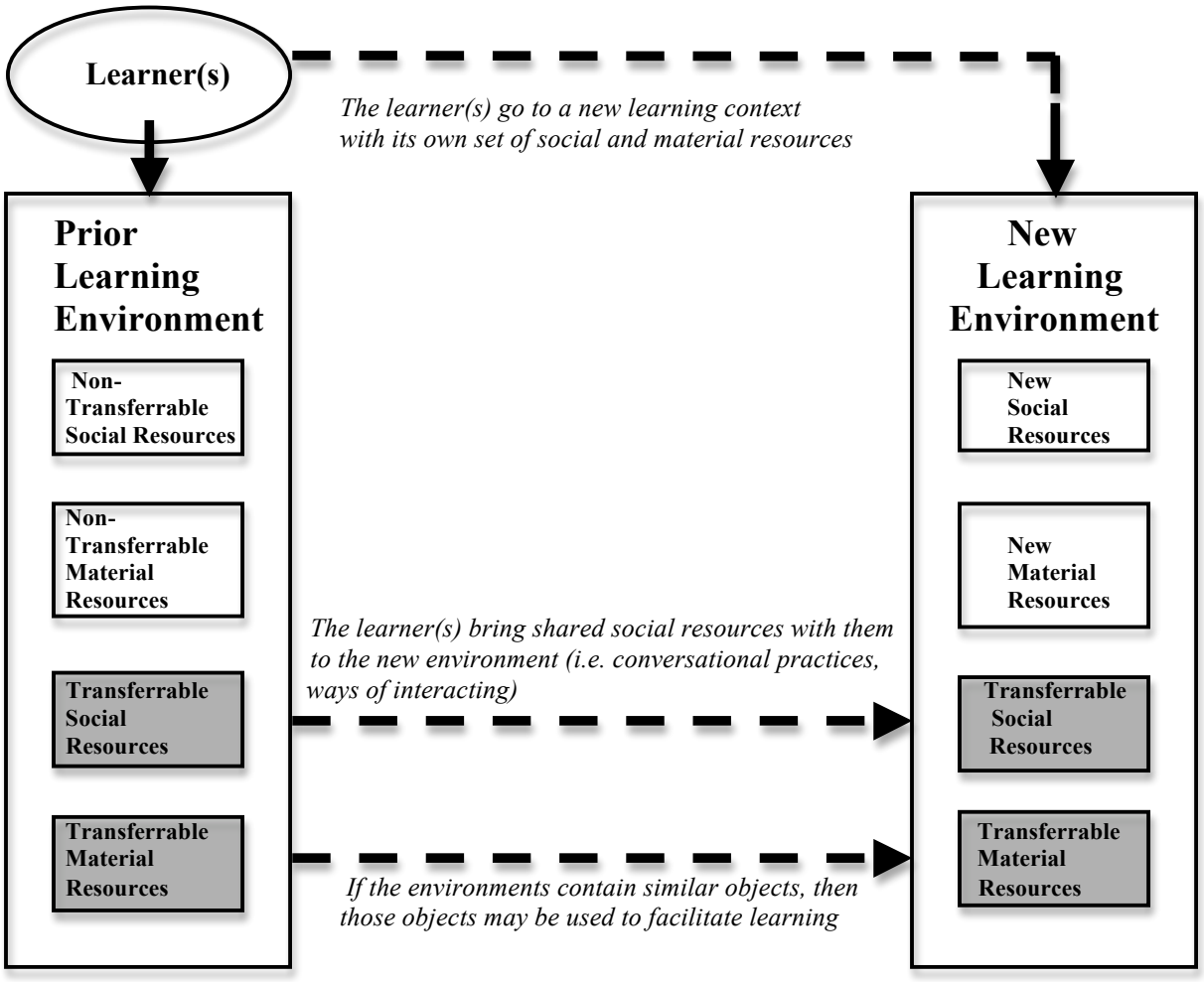

Figure 2. Learning in a Transferrable Resources Framework

The current study positions the family as a mobile learning unit[1] under the Transferrable Resources Framework. Here, the prior learning environment is a designed museum experience. As families move from the museum environment to other potential learning spaces, they take with them a shared history of talking and learning about topics encountered in the museum that we hypothesize can transfer to other environments that those families commonly interact within,

[1] Although this research study focuses on parents and children, a family unit can include other family members such as stepsiblings, grandparents, uncles and aunts, etc.

such as the home. Specifically, we predict that engaging in learning talk in a scaffolded museum setting will increase the amount of learning conversations parents and children have together at home as well as increase children's individual understanding of museum topics. Based on the Transferrable Resources framework, we have identified everyday objects viewed in the museum and encountered at home as possible facilitators of conversation and individual knowledge transfer.

2.2 IDENTIFYING TRANSFERRABLE LEARNING RESOURCES

The following sections describe the resources available to the family learning system in a Transferrable Resources framework. We will first focus on the main social resources available to families: the learning conversations they have with one another. We will then discuss how collaborative conversations contribute to children's learning, and identify four different aspects of talk that have been frequently linked to learning outcomes.

Next, we will turn our attention to how the environment itself can support learning. Since two learning environments, museums and the home, are of interest for the current study, research on learning within these two settings will be described and compared. We will also present some preliminary evidence in support of our framework, indicating that knowledge and ways of talking can be transferred from one learning environment to another. Finally, we will explore one of the assumptions of the current study: that family interactions around transferrable material resources like everyday objects in the museum can position those objects in an educational context that supports how families talk together when they encounter similar objects at home.

2.3 CONVERSATIONS AS A LEARNING RESOURCE

In many content areas, there is a strong link between what children talk about with their peers, teachers, and other adults, and what they subsequently learn about the world around them (Cazden, 2001; Leinhardt & Knutson, 2004; National Research Council, 2007). When children talk about domains like science and engineering with others, they are simultaneously building a shared understanding of specific content and learning how to use the language of a scientist or an engineer to express their ideas. These learning conversations are effective because they facilitate the development of children's content literacy by allowing them to rehearse the conversational practices of a discipline with knowledgeable partners in scaffolded settings (Ash, 2002).

There is some evidence from both memory and problem solving studies that suggests that children learn more effectively through conversational collaboration. Memory studies have shown that children tend to remember activities and objects that they and their parents looked at or did together, but only if they also talked about those objects and activities together during the experience (Haden et al., 2001; Tessler & Nelson, 1994). Problem solving studies have found that children spend more time on-task, and learn more about a topic when they are with an adult than when they are alone. Researchers have theorized that one possible reason that groups are more successful problem solvers than individuals is because joint collaboration distributes the amount of knowledge an individual has to have about a topic, and reduces the cognitive load on memory (Pontecorvo, 1993). Thus, when adults and children talk together to try to understand a topic, they are able to learn more effectively because they are sharing their knowledge with one another and constructing a joint, rather than an individual, conceptual framework. In fact, parents often serve as children's main conversational partners, actively participating in learning talk to

build understanding (Jipson & Gelman, 2007; Snow & Kurland, 1996; Waxman & Medin, 2007).

While it is clear that parent-child conversations are contributors to and indicators of learning, how does one determine what constitutes a "learning conversation"? We propose that the presence of the following four characteristics in adult-child talk determines whether a particular interaction contains a learning conversation:

- Involves talk around content
- Takes on an explanatory stance
- Connects to prior experiences or ideas
- Provokes curiosity through questioning

Each of the elements above have not only been linked to children's learning about the world, they also have been identified as core characteristics of authentic practice. Therefore, a conversation in a formal setting like a classroom or laboratory, or informal setting like a museum or the home, is considered to involve learning if it includes one of these features.

2.3.1 Learning Conversations Involve Talk Around Content

In order to talk like an expert on a particular topic, one has to adopt the language of the discipline (Brown & Spang, 2008). Discipline-specific talk is important when learning about a domain because it helps to guide learners' attention towards salient features of the phenomena being discussed, and arranges content within a real context (Allen, 2002; Callanan & Jipson, 2001). Swartz and Crowley's (2004) defined content as "knowledge and skills that [build] towards bigger ideas in specific disciplines: identifying concepts such as gravity, sounds waves, or transparency…, phenomena such as how instruments work or how traffic flows, and explicitly [mentioning] a discipline such as art, science, math, or music." Here, the language used by the learner to describe a particular phenomenon does not have to be formal. Rather, the learner can

use common vernacular that gets at the same ideas, and begins to approach how an expert would talk about the phenomenon (Brown & Spang, 2008). In this way, learners can build content understanding by appropriating terminology and ways of talking about ideas that mirror authentic conversations and practices.

Most early experiences with a discipline occur during childhood (National Research Council, 2009). For example, in informal settings like museums, families use structured talk, like naming and classifying objects, to compile information about a particular concept across exhibit experiences (Ash, Crain, Brandt, Loomis, Wheaton, & Bennett, 2007). At home, everyday parent-child conversations also cover a rich range of topics including scientific domains like physics and biology (Tenenbaum & Callanan, 2008, Blum-Kulka, 2002). Parents may not think that conversations during routine activities such as cooking a meal are educationally relevant, but there is evidence that such conversations support children's later understanding of domains like science (National Research Council, 2009). Furthermore, when parents and children focus in on content involving processes, they learn more about the topic, and talk significantly less about the superficial features of activities and objects that they do together (Snow & Kurland, 1996). These findings indicate that families who have opportunities to talk about content together in informal environments like museums and the home are able to incorporate process language into their jointly constructed understanding of a phenomenon.

2.3.2 Learning Conversations Take an Explanatory Stance

In the most general sense, explanations are bits of information that account for a phenomenon (Wilson & Keil, 1998). Although there are several recorded instances of self-explanation in which an individual verbalizes his or her thought processes around an idea (Chi, de Leeuw, Chiu,

& LaVancher, 1994), most explanations exist within dialogues between two or more people who use explanatory talk to build a shared conceptual understanding (Aukrust, 2002; Beals, 1993). When used in conversation, explanatory talk becomes a powerful way to discuss content and engage in authentic practices (Callanan, Shrager, & Moore, 1995; Crowley & Galco, 2001; Snow & Kurland, 1996; Tenenbaum, Snow, Roach, & Kurland, 2005). In particular, when adults give explanations to children, they encourage children's own use of explanatory language (Peterson & French, 2008), deepen children's engagement with the object or activity being talked about (Callanan & Crowley, 1998), and contribute to children's overall learning about the topic being discussed (Bargh & Schul, 1980; Dansereau, 1988; Fuchs et al., 1997; Pressley et al., 1992). In fact, children's ability to understand adults' explanations and produce explanations of their own is predictive of their later academic achievement (Beals, 1993; Snow & Kurland, 1996). In sum, studies of the use of explanations in adult-child conversation agree that explanatory talk is beneficial to children's learning.

Barberi, Colavita, and Scheur's (1990) defined an explanation as "an interactional move that occurs when one partner offers a new piece of information referring to an object, event or piece of information of joint attention." Barbieri et al.'s conversation-centric definition reflects a shift in the field from privileging causal "why" explanations to including more descriptive "how" explanations. This shift has occurred, in part, because researchers recognize that reasoning within domains like engineering involves a more complex discussion of mechanism in order to explain the process through which a cause leads to an effect (Carey, 1995; Koslowski, 1996; Machamer, Darden, & Craver, 2000; Russ et al., 2008; Schauble, 1996; Springer & Keil, 1991). During engineering activities like building and making, causal explanatory frames seem less appropriate than process explanations focusing on how things work (Gleason & Schauble, 1999;

Schauble, Leinhardt, & Martin, 1997). In fact, the current study takes place within an exhibition that explores how everyday objects are made, situating it within the domain of engineering. Thus, we are examining the use of process explanations in an engineering context.

Without mediation, the complex processes and underlying mechanisms that govern phenomena often go unnoticed, especially by children, in favor of surface features (Penner, Giles, Lehrer & Schauble, 1997). In formal contexts, children seem to be proficient in providing causes to account for natural phenomena, but they have difficulty explaining the process (i.e. how) through which those phenomena were produced (Abrams & Southerland, 2001; Southerland, Abrams, Cummins, & Anzelmo, 2001). Abrams and Southerland (2001) believe that children's difficulty stems from the way domains like science are taught in school. School science focuses on causal explanations, and provides children with limited opportunities to practice constructing process explanations. Yet what about informal environments? Do they provide a forum for children to rehearse process explanations with their families?

The exploration of process explanations in informal environments is a relatively new concept. Yet there is some preliminary evidence that museums are well-suited locations for families to engage in learning conversations that take an explanatory stance. Eberbach and Crowley (2005) examined several different types of explanations within family conversation in a botanical garden. They found that, although the total amount of explanations families use during the course of a conversation is small compared to other types of talk, the majority of explanations families used while talking about natural phenomena were process explanations. These findings suggest that families are able to incorporate process explanations (i.e. descriptions of how and what is happening) into their co-construction of knowledge about the discipline, object, or activity being discussed.

2.3.3 Learning Conversations Connect To Prior Experiences

When an individual is confronted with a novel phenomenon, he or she integrates prior knowledge and everyday experiences in the world with new ideas in order to contextualize a conceptual understanding of that phenomenon in a personally meaningful way (Ansbacher, 1999; Hein, 1998; Rounds, 1999; Silverman, 1995). Connecting past and present ideas and activities together is a way for learners to rehearse content and encode complex concepts into memory (Belmont & Butterfield, 1971; King, 1994; Wittrock, 1990). In fields like chemistry and biology, scientists engage in conversations with their colleagues that connect prior experiences to novel concepts in order to contextualize their work, a practice that can lead to new breakthroughs (Dunbar, 1995).

Adults also interpret novel objects, activities, and ideas for their children by referencing shared experiences that position new concepts into a context that is more familiar, helping children to build upon their prior knowledge (Callanan & Jipson, 2001; Tessler & Nelson, 1994). Family conversations in informal settings like museums often involve references or comparisons to past events or information (Hilke, 1987). For example, Crowley and Jacobs (2002) reported the following conversation in a natural history museum between a mother and son looking at replica fossils:

> *Boy (B):* Hey! Hey! A velociraptor! I had that one my [inaudible] dinosaur.
>
> *Mother (M):* I know, I know, and that was the little one. And remember they have those, remember in your book, it said something about the claws…
>
> *B:* No, I know, they, they…
>
> *M:* Your dinosaur book, what they use them…
>
> *B:* have so great claws so they can eat and kill…

M: they use their claws to cut open their prey, right.

The excerpt above demonstrates how references to prior experience are used by parents to explain phenomena that they and their children are both engaging with (Allen, 2002; Eberbach & Crowley, 2005).

Such connective talk has been shown to contribute to visitor learning (Leinhardt & Knutson, 2004). In fact, children whose parents made personal connections to content during a museum experience demonstrate more content understanding after their visit than children whose parents made no such links (Crowley & Jacobs, 2002). Thus, making connections to prior experiences helps learners contextualize new information, and integrate it into a more cohesive understanding of the phenomena being explored.

2.3.4 Learning Conversations Provoke Curiosity Through Questioning

The way that children ask questions about the world has been likened to the way that scientists generate new ideas (Simon, 2001). Like scientists, children's curiosity often motivates them to ask "why" questions in order to find out what caused the phenomena they are viewing (Gopnik, Melzoff, & Kuhl, 1999; Heath, 1999; Pressley et al., 1988; Tizard & Hughes, 1984). In the current study, questions that provoke curiosity are defined as queries that "encourage open-ended description" of phenomena or an expansion of conceptual understanding (Ex. "How did you move it?" and "Why did they make it like that?") (Hohenstein & Tran, 2007). Such "wonderment" questions are considered powerful conversational tools because their use can lead to significant changes in conceptual understanding (Scardamalia & Bereiter, 1992).

During collaborative conversations, adults use questions to direct children's attention to salient objects or ideas that are important to recognize in order to understand the phenomena (Boland, Haden, & Ornstein, 2003; King, 1994). Adults also use questions to encourage children

to ask questions of their own (Ash, 2002; Wells, 1999), and provide explanations for the phenomena being viewed or topic being discussed (Blum-Kulka, 2002; Chin et al., 2002; Hoff-Ginsberg, 1991; Scardamalia & Bereiter, 1992). In this way, questions give children a way to talk about content and elaborate on previously discussed ideas (Engle & Conant, 2002; Roth, 1996).

The questions that adults and children ask can reveal their conceptual understanding of the topic. Yet the kinds of questions being asked in formal settings such as schools are not often connected to deep learning. In schools, teachers and students both tend to ask basic fact-seeking questions that require short recall responses (Gall, 1970; White & Gunstone, 1992). Such questions do not scaffold deep thinking (Chin et al., 2002). Instead, questions that require the answerer to provide an explanation seem to be the most productive in extending children's knowledge about a topic (Scardamalia & Bereiter, 1992). However, even when rich questions are asked, it does not guarantee that an answer will be given. This is problematic, since low levels of questioning and answering in classrooms has been linked to lower achievement (Swing & Peterson, 1982).

In informal settings like museums, parents often ask their children questions to make what parents already know explicit, to ensure that their child understands the activity, and to encourage family conversations to continue (Ash, 2004). This conversational practice within museums is important because family talk that includes a question being asked or answered is significantly related to learning (Borun, Chambers, & Cleghorn, 1996). In fact, when parents ask open-ended questions during a shared experience, their children remember more about the experience, report learning more, and are able to provide more sophisticated definitions of domains like science than children whose parents did not ask such questions (Hohenstein,

Callanan, & Ash, 2005; Ornstein, Haden, & Hedrick, 2004). Interestingly, when exhibitions are specifically designed to invoke curiosity, visitors tend to ask more questions related to using the exhibition and understanding its content (Hein, Kelley, Bailey & Bronnenkant, 1996; Humphrey & Gutwill, 2005). Therefore, a museum exhibition that elicits more open-ended than close-ended questions can be considered a location where visitors' curiosity is being provoked and learning is taking place.

2.3.5 Conversations Across Multiple Contexts Aid Family Learning

We propose that families rehearse ways of talking together in museums in ways that change their discussions around content at home. Implicit in this claim is the idea that conversational memory is how information moves across contexts. We know that talking together during a museum experience affects what visitors remember about that experience (Anderson, Storksdieck, & Spock, 2007). Families are more likely to remember an exhibition after their visit, if a conversation took place there (Cone & Kendall, 1978; Stevenson, 1991). In fact, conversation is such an important aspect of the museum experience that children are unable to recall objects that they saw in an exhibition, if they did not talk about those objects with others (Tessler & Nelson, 1994). In other words, recall of prior conversations and activities can cue individual memories of specific content.

Conversations can also play a more active role in the recall of an idea. Families can actively rehearse their museum visit by discussing their experiences with others (Falk & Dierking, 1990; Stevenson, 1991), or engaging in complementary activities like reading books on a topic they encountered within an exhibition (Medved, 1998; Tully & Lucas, 1991). In general, talking about and interacting with objects that reference a prior event like a museum

visit, positively impact what individuals remember about the event itself, and improves subsequent learning (Anderson, Lucas, Ginns, & Dierking, 2000; Carr, 1991; Holtzblatt & Jones, 1993; Sehulster, 1989). By linking ideas from a previous museum experience to conversations in everyday settings, families can also build upon their shared content understanding (Anderson et al., 2002; Luke, Coles, & Falk, 1998; Luke, et al., 1999). In contrast, if families do not engage in these reinforcing experiences, their memory of the original museum visit will decline, although they still will have more understanding of the topic than they did before the visit (Storksdieck, Ellenbogen, & Heimlich, 2005). These findings suggest that post-visit experiences, which allow families to discuss and connect ideas encountered at the museum, might facilitate a deeper comprehension of exhibit content.

Studies of school-to-home connections support the idea that children are able to transfer discipline-specific ideas and ways of talking that they rehearsed in one location to everyday contexts like the home. Fleer (1996) found that after children participated in a preschool science program, they asked more scientific questions at home. Parents also discussed more science-related content and performed more scientific investigations at home after their children had participated in the program. Fleer's study implies that encountering content first in a scaffolded setting, allows families to practice how to talk about relevant ideas, so that they are better able to engage in learning conversations and activities once they return home.

So, what is the benefit to families of rehearsing content in more than one environment? Often, the salient aspects of an informal experience are not recognized until a later activity triggers connections to ideas that give the learner a way to think and talk about the content (Wolins et al., 1992). In fact, children who engage in experiences that contain the same content at school and at home retain knowledge about that content better than children who just

encounter the material at school (De Lurdes Cardoso, 2002). These children take a more active part in topic-related activities and conversations at home with their parents, and are able to integrate the formal and informal experiences together into a cohesive content understanding (De Lurdes Cardoso, 2002). Here, it seems that exploring an idea in more than one environment, in particular with one's family, helps learners form a better understanding of the discipline.

Based on the findings above, we think that family conversation during a museum visit can change how families talk at home in three ways. First, talking together in the museum helps families to better remember their experience after their visit. Second, discussing ideas first encountered in the museum in another setting provides families with another chance to rehearse how to talk about the content. Lastly, talking about the museum's content in a place like the home, encourages the family to make connections between the past and present experiences that expand upon and integrate their content understanding.

2.3.6 Synthesizing the Characteristics of Learning Conversations

In sum, we think that four characteristics define a learning conversation: content talk, process explanations, prior experience references, and open-ended questions. An increase in parent-child talk in any of these four areas from one learning environment to another would be seen as strong evidence that families were rehearsing learning conversations in one environment, helping them to become better at talking together about a particular topic in subsequent settings. In the current study, an increase in the four areas of learning talk from before the museum experience to after the visit and later at home would support our hypothesis that the shared museum experience helps families transfer learning talk into the home environment.

2.4 INFORMAL ENVIRONMENTS AS LEARNING RESOURCE

Although worthwhile learning conversations can and do occur in school settings, children are only in school nine percent of their lives (Sosniak, 2001). Therefore, children's opportunities to practice content-based discourse in the classroom are limited compared to the amount of time they spend outside of school with their families. Outside of school, parents and children interact with one another in everyday settings like the home or in designed learning environments like museums. In these informal settings, parents become their children's learning partners, engaging in joint-exploration of the world around them through participation in shared activities and conversations (Hilke, 1989; Snow & Kurland, 1996).

The current study focuses on how shared experiences in museums can affect what and how families talk at home. In order to explore this topic, we must determine the following: 1.) How the home functions as a learning environment, 2.) How the museum functions as a learning environment, 3.) How the museum and the home compare as learning environments, and 4.) Whether there is evidence that ways of talking can be transferred from one learning environment to another.

2.4.1 How Does the Home Function As a Learning Environment?

What makes the home an advantageous learning environment? Tizard and Hughes (1984) identified five reasons that the home is an effective learning context. First, parents and children can take part in a wide range of activities within the home. These activities, such as getting ready for school, eating meals together, playing with toys, and doing homework, naturally encourage conversational interaction (Gallimore & Goldenberg, 1993). Furthermore, parents talk to their children differently depending on what activity the family is engaging in (Hoff-

Ginsberg, 1991). This means that the variety of activities families engage in on a daily basis provide multiple opportunities for families to discuss different disciplines, a feature characteristic of powerful learning conversations.

Second, parents and children share common experiences, so they can call upon prior knowledge to explain what they are currently looking at or doing. For example, during meals, adults sometimes explain social or natural phenomena to their children by referencing time spent together in other settings (Aukrust, 2002; Hickling & Wellman, 2001; Keppler & Luckmann, 1991). Such naturally occurring explanatory behavior has been positively linked to children's later language development and school achievement (Snow, 1991). In other words, families learn together by linking their home experiences to the outside world in order to provide explanations, two components of powerful learning conversations.

Third, at home, adults are able to collaborate more with children, spend more time with them, and focus on what children are saying in more detail than they would be able to in formal environments like school where the teacher must attend to multiple students at once. In school, children tend to initiate fewer interactions, ask fewer questions, and engage in fewer conversational turns overall than they do at home (Wells, 1986). In fact, the quantity of adult-child talk is four times greater at home than it is at school (Tizard & Hughes, 1984).

More specifically, at school, children typically ask two questions per hour, while at home young children ask an average of twenty-six questions per hour (Tizard & Hughes, 1984). The quality of questions children ask at home is also richer than those they ask at school. For instance, at home, two-thirds of the questions children ask are curiosity questions (i.e. questions asked with the purpose of seeking information that helps children understand the world around them) (Tizard & Hughes, 1984).

The differences in the quality and quantity of children's home and school discourse have been attributed to the nature of classroom culture. In classrooms, students are expected to provide answers to teachers' questions, rather than ask questions of their own. Furthermore, teachers tend to dominate the conversation in the classroom, whereas conversations are more evenly distributed and collaborative at home (Tizard & Hughes, 1984; Wells, 1986). Thus, conversations at home appear to have more characteristics of rich learning experiences, such as provoking curiosity through questioning, than student talk within the classroom. There are simply more opportunities for children to practice how and what to talk about during conversations at home than there are at school.

Fourth, the learning that occurs at home is embedded in rich activities that often have personal meaning for the child, versus at school where external motivations and meanings must be constructed that lack an authentic context. For example, conversations around the dinner table involve sharing stories about one's day, negotiating the rules of the house, and obeying parents' requests (Kim, 2006). These personally meaningful interactions are full of rich linguistic patterns that help children learn how to talk like adults (Blum-Kulka, 2002; Tomasello, Conti-Ramsden, & Ewert, 1990). The presence of these conversational opportunities may support children in using more sophisticated reasoning about science and the natural world at home than they do in formal settings (Bell et al, 2006; Sandoval, 2005).

Finally, parents and children have a closer relationship than children do with their teachers, meaning that parents and their children can feel comfortable talking and learning together in the home environment. All of these factors combined, make the home a productive learning environment.

2.4.2 How Does the Museum Function As a Learning Environment?

Museums are places where conversation is both a social process and a tool to construct a better understanding of the world. By engaging in collaborative activities together, families are able to use museums to rehearse powerful ways of talking about the ideas and objects that they encounter during their visit. In particular, elements of the learning environment such as signage mediation, the presence of real objects, and an abundance of rich, varied activities help facilitate family interactions and guide families in what to do at and how to talk about exhibitions together. In this way, museums provide families with a supportive venue to practice powerful learning conversations around content.

For families, the museum is a socially mediated learning environment (Astor-Jack et al., 2007; Dierking, 1987; Laetsch et al., 1980). The typical family spends about 15 to 20 percent of their visit interacting with one another (Falk et al., 1985). This percentage may seemingly position interaction as a small part of the overall visit, but for many families, the main purpose of going to a museum is to spend time together (Briseno-Garzon, Anderson, & Anderson, 2007; Litwak, 1993; Sanford, Knutson & Crowley, 2007;).

When families experience museums together, they negotiate shared goals and tasks, and work with one another to develop a shared understanding of exhibit content (Dierking, 1989). Interacting together provides more opportunities for families to build knowledge around exhibit content than they would have if they experienced the exhibit separately. In fact, children who visit a museum exhibit with their parents tend to stay at the exhibit for a longer amount of time and engage more deeply with the exhibit than children whose parents do not actively participate with them during the activity (Crowley & Callanan, 1998; Puchner, Rapoport & Gaskins, 1997).

This finding suggests that family collaboration leads to richer and more productive learning experiences in museums.

During family interactions, conversation is a pivotal mechanism, which guides families' informal activities and helps them filter larger concepts and ideas through a shared perspective (Ellenbogen, Luke, & Dierking, 2004; Falk & Dierking, 1992; Hensel, 1987; Silverman, 1990). When family members talk with one another in museum contexts, they take information from the learning environment and re-interpret it with their conversational partners (Ash, 2002; Hilke, 1989). As families begin to build a collective understanding of phenomena through the sharing of ideas, they learn about different aspects of the environment and about each other (Zimmerman, Reeve, & Bell, 2008). In this way, families are able to find opportunities within informal contexts to practice ways of talking together that contribute to the formation of a family culture as lifelong learning partners.

Certain kinds of talk, such as explaining the way that something works, applying one's own personal experiences to a content topic, and describing what one is seeing to someone else contribute to the development of shared knowledge within museum contexts (Borun, Chambers, & Cleghorn, 1996; Leinhardt & Knutson, 2004; Rosenthal & Blankman-Hetrick, 2002; Taylor, 1986). However, "explanatory engagement", a category of conversation that includes analysis, synthesis, and explanation of information or activities, is considered to be one of the richest ways that families can talk together in museums (Leinhardt, Crowley, & Knutson, 2002). Two characteristics of powerful learning conversations are embedded in this category: Taking an explanatory stance and connecting to prior experiences. Thus, it is no surprise that explanatory engagement has been found to be the most influential factor to account for group learning in museums (Leinhardt & Knutson, 2004).

Museum exhibitions are designed to support these powerful learning conversations in a number of ways. First, museums provide families with opportunities to engage in a wide variety of activities, and give them access to both familiar and unfamiliar objects. These activities can range from experiences with real artifacts to animated movies, computer interfaces, and hands-on interactives, (Vance, 1991). For the most part, visitors seem to remember more exhibit content, interact with one another more, and learn more when they actively, rather than passively engage, in exhibit activities (Blud, 1990; Koran et al., 1984; vomLehn, Heath, & Hindmarsh, 2001). Since exhibits have different affordances that affect what visitors can do and talk about during their visit, being exposed to several types of objects and activities makes it more likely that families will collaborate with one another and have rich discussions around some of the museum content.

In particular, encounters with real objects elicit questions, explanations, and connections to prior experiences, which are all characteristics of powerful learning conversations (Eberbach & Crowley, 2005; Hohenstein & Tran, 2007; Paris, 2002). Leinhardt and Crowley (2002) claim that visitors are able to learn from objects in museums due to four factors: resolution and density of information, scale, authenticity, and value. In other words, having the opportunity to experience the actual object is better than seeing a picture or engaging in a fake activity because you can see and sense more details from the object, make size comparisons between self and object, view the real thing rather than a representation, and create a personal connection with the artifact.

Another reason that Leinhardt and Crowley (2002) think that museum objects support learning conversations is because objects are case-based examples of ideas. Research in formal environments has shown that concrete examples of phenomena help students learn new concepts

(Atkinson, Derry, Renkl, & Worthham, 2000). In a similar manner, objects in informal environments often serve as examples of content categories (Bain & Ellenbogen, 2002).

In museums, the way in which objects are displayed or interpreted helps visitors form stronger connections between object examples and the larger ideas to be learned (Conn, 1998). Context is such an important part of discipline-based understanding that if an object is moved out of a mediated museum context into another setting, how learners understand and talk about that object can change (Siegel & Szechter, 2006). For instance, an Acorn Weevil can be displayed in a case amongst other bugs as a type of beetle found in North America, or it can be placed in a jar of formaldyhyde to demonstrate preservation techniques used by entymologists. Both displays contain the same object, but the way in which the Acorn Weevil is presented as an example leads learners to form very different conceptions. Here, the way that the museum interprets objects scaffolds visitor understanding by helping visitors focus on salient information about those objects, rather than superficial features that might not contribute to visitor learning. This is how museums facilitate visitors' meaning-making around objects (Hein, 2007).

Museum exhibitions also mediate complex concepts using linguistic, contextual, and sensory cues to help visitors understand the idea behind the phenomena, object, or activity being displayed (Hein, 1998; Hohenstein & Tran, 2007; Humphrey & Gutwill, 2005). Research has shown that visitors tend to learn more from objects that have these interpretive labels than from objects that are displayed without overt interpretation (Allen, 2004; Peart, 1984). By parsing information into more easily understood language, museums are able to communicate ideas in a way that gives families conversational tools and terminology they can use to talk about the exhibit together. For example, if signage at a museum exhibit about racecars asks, "How is this racecar different than the car you have at home?", that signage is inviting families to make

comparisons between their prior experiences and the object currently being viewed. Signage like the example above helps families begin to make sense of the object that they are looking at, and gives them a powerful way to talk about that object.

If families recognize the supports present within the museum environment and continue to incorporate both the content and ways of talking that are being scaffolded, then they will eventually become "museum literate" (i.e. competent at meaning-making around exhibit objects and activities) (Stapp, 1984). Here, the museum environment becomes more than just a place to spend time with one's family. Families come to view the museum as a supportive rehearsal space that provides them with mediated opportunities to explore how, in addition to what, they learn together (Palmquist & Crowley, 2007).

2.4.3 How Do the Museum and Home Compare As Learning Environments?

Although it seems clear that families engage in aspects of meaningful learning conversations in both museums and the home, how do these conversations differ? For one, parents seem to engage in more collaborative conversations around content in museums, and be more directive when exploring discipline-specific ideas and activities with their children at home (Siegel et al., 2007). This finding makes sense when we consider that one of the main goals of families in museums is to spend time together, and one of the main goals of being at home is to grow into an adult. Therefore, parents may take on a more teacherly role at home because they are trying to socialize their children and prepare them for adulthood.

Alternatively, recent research on parent-child science conversations suggests that parents may engage in more explanatory talk at home than they do during visits to places like museums (Tenenbaum & Callanan, 2008). This result seems to indicate that the home may be a better place for families to rehearse learning talk than museums. However, we provide an alternative

explanation. The order of events in Tenenbaum and Callanan's study was not counter-balanced, so families always visited the museum before they talked together at home. Therefore, their finding that families engaged in more explanatory talk at home may be evidence that families were rehearsing explanatory talk in the museum setting, helping them to become better at explaining during subsequent shared experiences. If this is the case, then families who visit museums more often, should talk together more frequently at home because they have had more opportunities to learn how to talk together than families who do not visit museums. Supporting this idea, Tenenbaum and Callanan found that families who frequently visited museums gave significantly more explanations to their children while talking together around science-based activities at home than families who have not had such experiences. Thus, Tenenbaum and Callanan's study supports our hypothesis that rehearsal of learning conversations within a museum setting may affect how families talk together at home.

2.5 ORDINARY OBJECTS AS LEARNING RESOURCES

One of the assumptions of the current research is that encounters with everyday objects in museums position those objects in a new way that will support how families talk about those objects at home. In order to test this assumption, we must first establish that families' conceptions of objects at home are fundamentally different than their ideas about objects in museums. For the most part, objects in the home tend to be viewed in terms of the function that they have (Siegel, 2007). For example, a cup is used for drinking. In contrast, objects in museums are often positioned as tangible examples of a category such as a time period, natural phenomena, or discipline (Bain & Ellenbogen, 2002; Leinhardt & Crowley, 2002). Here, we see

that objects in the home are thought of in the context of the activity that they are part of, whereas objects in museums are meant to represent larger ideas. Thus, families are consumers of objects at home, but are considered to be learners about objects in museums. If families were able to reposition their understanding of objects at home as things to learn from, then they might take more opportunities at home to talk about and build an understanding of the everyday world using objects as conversational facilitators.

In audience-focused learning environments like children's museums, familiar topics are sometimes presented alongside novel topics. Comparisons of children's behavior at familiar versus novel content exhibits have revealed that exhibits with familiar content are more attractive to children, hold their attention longer, engage them in more interactions with their parents, and help them create a more meaningful interpretations of exhibit contents (Gallagher & Dockser, 1987; Sykes, 1993). This finding is not surprising since visitors bring their own personal and cultural history to their experiences with an object (Evans, Mull, & Poling, 2002; Gurian, 1999; Paris & Mercer, 2002). Museum visitors likely gravitate towards familiar objects and activities because those experiences support more opportunities for the visitors to link their personal recollections with newly encountered ideas. Therefore, if learners are drawn to objects that they recognize or have personal connections to and tend to talk about such objects with other people, then it seems that organizing ideas around recognizable, everyday objects would be the best way for museums to scaffold the learning of difficult concepts for families and other visitors.

There is some evidence from school-to-home studies, supporting the idea that everyday objects facilitate content-based learning conversations. In a study of a preschool science curriculum, Fleer (1996) discovered that many parent-child conversations around science occurred on occasions where a child encountered an everyday object, like a cooking utensil, that

he or she previously encountered in the preschool program. The researcher concluded that encountering everyday objects at home that had been previously viewed and discussed in a scaffolded learning context, stimulated children's recall of science content and allowed children to have learning-oriented conversations with their parents around those objects.

Other studies have found that parents are also able to contextualize authentic practices into everyday activities (De Lurdes Cardoso, 2002). For example, Hall and Schaveren (2002) conducted a six-month study during which families were given science kits in order to investigate how parents and children engaged in scientific activities at home together. The kits included familiar objects like flashlights because the researchers thought that more recognizable objects would help children think more deeply about scientific ideas. They found that parent talk about science was often triggered by everyday events in the family's lives or children's questions about phenomena such as boiling water. Children were able to generate explanations about these phenomena using resources provided by their parents and through conversational collaborations. The authors concluded that it is important to provide learning opportunities for families to conduct investigations of familiar objects and activities in the home, so that parents and children can rehearse scientific practices and conversations that help them build an understanding of science and technology together.

Taken together, findings from multiple learning environments indicate that familiar objects have great potential to support conversations about and interactions around content in both museum and home settings. In particular, first talking about an idea using an everyday object in a scaffolded setting, helps families learn how to talk about that topic using everyday objects at home. Likewise, the current study focuses on family learning conversations around

everyday objects in museums, and how the shared museum experience mediates the ways in which families talk about the concepts behind the making of everyday objects in their homes.

3.0 METHODOLOGY

3.1 PURPOSE OF THE STUDY

The goal of the current study is to explore whether participation in a shared museum experience can facilitate learning conversations at home. Specifically, we wanted to know whether families who visited a museum exhibition on the topic of manufacturing became significantly better at talking about how everyday objects are made once they returned home. Therefore, we designed this study to investigate the following questions:

1.) Does the learning talk families engage in during a shared museum visit increase the amount of learning conversations families have at home?

2.) Does the learning talk families engage in during a shared museum visit support an increase in children's understanding of the processes used to make everyday objects once they return home?

3.) Under what circumstances do learning conversations about everyday objects occur at home?

3.2 DESIGN OF THE STUDY

In order to pursue these questions, we used a mixed-methods approach to collect data from families in the museum and in their homes at five different timepoints: before the museum visit, during the museum visit, immediately after the museum visit, before the home visit, and during the home visit (See Table 1).

Before the museum visit began, families participated in a joint activity consisting of two parts to assess the families' learning talk. In part one, families were shown four real objects, representing four different manufacturing processes, and were asked to talk together about how those objects were made. In part two of the joint activity, families were shown pictures of four pairs of objects and asked to provide their reasoning regarding whether they thought those objects were made in a similar way of a different way. After the completion of the joint activity, children were separately interviewed in order to assess their individual understanding. These interviews followed a similar format to part two of the joint activity, except parents wrote down their answers and children provided verbal responses to the researcher. At the conclusion of these assessments, parents answered a survey of demographic questions regarding their interest and experience with the topic of manufacturing in order to identify other possible factors that could account for changes in learning talk and understanding.

After families finished the joint and individual assessments, they were led to the entrance of the How People Make Things exhibition and instructed to talk together as they would during a typical museum visit. The families were videotaped in order to record their conversations during their visit to the exhibition. When the family exited the exhibition, they were again assessed using the joint activity and individual interview protocols, albeit with different objects. At the

conclusion of these tasks, parents were given journals to track their conversations around everyday objects for the two weeks in-between the museum and the home visit.

Two weeks after the museum visit, families again participated in the joint activity and individual interview assessments, this time, in their homes. After these tasks were completed, families took part in a two-part scavenger hunt activity to further establish whether their learning conversations had changed. In part one of the scavenger hunt, families were shown a real object and were asked to work together to find an object in their homes that they thought was made in a similar way. In part two, families were asked to find objects in their homes that were made using four different manufacturing processes that had been the focus of the museum exhibition. For both portions of the scavenger hunt activity, families were asked to provide reasons for why they chose particular objects.

Table 1. Overall Study Design

<table>
<tr><td rowspan="8">Museum</td><td colspan="3">Timepoint 1: Before Museum Visit</td></tr>
<tr><td>Family Joint Activity</td><td>Parent & Child Individual Interviews</td><td>Family Demographic Survey (for parents)</td></tr>
<tr><td colspan="3">Timepoint 2: During Museum Visit</td></tr>
<tr><td colspan="3">Family conversations are videotaped while they go through the How People Make Things exhibition</td></tr>
<tr><td colspan="3">Timepoint 3: Immediately After Museum Visit</td></tr>
<tr><td>Family Joint Activity</td><td>Parent & Child Individual Interviews</td><td></td></tr>
<tr><td rowspan="4">Home</td><td colspan="3">Timepoint 4: Before Home Visit (two weeks in length)</td></tr>
<tr><td colspan="3">Parents write in journals to record family conversations about how everyday objects are made</td></tr>
<tr><td colspan="3">Timepoint 5: During Home Visit</td></tr>
<tr><td>Family Joint Activity</td><td>Parent & Child Individual Interviews</td><td>Scavenger Hunt Activity</td></tr>
</table>

The overall design of the study makes it possible to analyze family learning outcomes such as talk and individual understanding in several ways (See Table 2). The repetition of the joint activity and individual interview protocols across three time points allows us to look for changes in family learning talk and children's individual knowledge with a specific focus on four conversational characteristics that have been linked to learning. Because we also collected family talk data during the museum visit and during a scavenger hunt activity in families' homes, we have some qualitative basis for any claims that we make about the effect of a shared museum experience on family learning talk in the home environment. In addition, the parent journal data allows us to answer questions about the social, material, and environmental resources outside of the museum environment. These journal entries also give us a way to investigate whether there is any value added to having additional learning conversations after a shared museum experience. Finally, demographic information collected from participants allows us to compare families who have visited the museum exhibition before and those who are visiting the exhibition for the first time. By doing so, we can make a case for the shared museum experience as an agent of change, rather than attributing that change to the repeated questioning inherent in the study design.

Table 2. Analyses Based on Study Design

Research Question	**Information Needed**	**Data Sources**	**Analytical Procedures**
1.) Does what and how families talk about ideas during a shared museum visit increase the amount of learning conversations parents and children have at home?	Changes in family learning talk	Joint Activity at three time points	Repeated-measures ANOVAs looking at four characteristics of learning talk: a.) use of content b.) explanations c.) prior experience references d.) questions
	Nature of Family learning conversations in museums	Video recording during museum visit	Qualitative descriptions
	Nature of Family learning conversations at home after shared museum experience	Video recording during home visit of Scavenger Hunt Activity	Correlations with Joint Activity Data
	Identifying other potential agents of change	Demographic Survey	Multivariate ANOVAs to establish differences between groups
2.) Does what and how families talk about ideas during a shared museum visit facilitate the transfer of children's understanding around the topic of manufacturing and the processes used to make everyday objects to the home?	Changes in understanding	Child Individual Interviews at three time points	Repeated measures ANOVAs looking at three characteristics of learning talk: a.) use of content b.) explanations c.) prior experience references
	Identifying other potential agents of change	Demographic Surveys, Joint Activity, Individual Interviews	Multivariate ANOVAs to establish differences between groups
3.) Under what circumstances do learning conversations about everyday objects occur at home?	Social, material, and environmental resources available to the family	Parent Journals	Qualitative descriptions
	Determining value added of learning conversations after museum experience	Parent Journals, Joint Activity, Individual Interviews	Linear regression analyses

3.3 RESEARCH CONTEXT

This study took place at an NSF-funded travelling exhibition, *How People Make Things* (HPMT), focused on the topic of manufacturing. The exhibition was created by the Children's Museum of Pittsburgh in collaboration with Family Communications (FCI), and the University of Pittsburgh Center for Learning in Out-of-School Environments (UPCLOSE). HPMT was inspired by the Mister Rogers' Factory Tour videos, which tell stories of how everyday objects are made from raw material to finished product. The 2500 sq. ft. exhibition explores the people, processes, tools, and machines used to manufacture objects that are familiar to children.

The idea behind HPMT was to create a set of activities that helped visitors see the world through the eyes of an engineer (i.e. someone who focuses on the processes used to make objects), and downplay the viewpoint of the consumer (i.e. where objects are seen as finished products). Evidence from parent-child interactions in informal science settings, suggests that families are able to engage in rich discussions about processes in places like museums and the home (Callanan & Oakes, 1992; Eberbach & Crowley, 2005; Snow & Kurland, 1996). Thus, the HPMT exhibition was a good context for the current research because it is in an informal setting that was explicitly designed to support parent-child conversations around the processes through which everyday objects are made.

The exhibition focuses on four processes used to make everyday objects: Cutting, Molding, Deforming, and Assembly. HPMT was designed to provide families with multiple opportunities to interact with real machines and make everyday objects using each of the four processes. Signage throughout the exhibition encourages visitors to connect the processes done by hand to those done by machine. Narrated video clips use kid-friendly language to explain the

steps that are involved in manufacturing an object. All of the activities and objects in the exhibition were chosen to help families view objects as being made through processes.

3.3.1 Description of Activities Within the Exhibition

The first room of the exhibition is the Entry Area. The Entry Area was designed to create an opportunity for families to play the roles of factory workers, and highlight the importance of people in the manufacturing process. This area includes five activities: an Office, Lockers, Factories in Your Neighborhood, the People Game, and a Baseball Bat Display (see Figure 3). In the office space, parents and children can assemble large foam building blocks and wooden toy cars. The locker area was set up so families can put on lab coats, hard hats, goggles, and uniforms and compare their images in a mirror to those of real factory workers. Factories in Your Neighborhood is a wall of four window boxes containing recognizable objects made by four Pennsylvania factories. A photograph of workers from each factory as well as a description of the objects is attached to the wall. In the People Game, visitors press buttons to listen to audio clues of four real factory workers describing the process of making an object, and try to match those descriptions with pictures of each object. Finally, the Baseball Bat Display demonstrates five steps in the process of making a baseball bat. Families can touch and turn the bats on display.

Figure 3. Images from the Entry Area of the How People Make Things exhibition:

a.) Factories in Your Neighborhood and the Baseball Bat Display, b.) The Office and Lockers, c.) The People Game

The second room of the exhibition is the Molding Area. Activities in the Molding Area are meant to relay the concept that the molding process involves a material being added to a form to make a new shape or object. Exhibit components in the Molding Area include Molding with Wax, Fill-a-Mold, Mold Matching, an Injection Molder, the Crayon Display, a Rotational Ball Mold, the Pellet Wall, a Molded Artifacts Wall, and the Molding Video Wall. In Molding with Wax, families ladle warm wax into chilled open molds of a shoe sole, spoon, tire tread, and candy bar. When the wax cools, parents and children can scrape the solid object out of the molds and return it to the vat of warm wax, watching it melt back into a liquid. Fill-a-Mold is an activity in which parents and children pull a series of levers that fill empty plastic shells with blue liquid to reveal everyday objects like a comb, hanger, LEGO block, fork, and flyswatter. The activity is meant to simulate what happens inside of a closed mold during the injection molding process. In Mold Matching, visitors match objects like footballs, shopping cart wheels, and shoe soles to the industrial molds that they came from. When families press a button to activate a machine called the Injection Molder, they can watch plastic pellets melt and be injected into a closed spoon mold. A timer counts down the length of the process, and a burst of

air shoots the warm spoon down a shoot, so that the spoon can be picked up and taken home. Signage encourages visitors to compare the mechanical Injection Molder to the hands-on activity, Molding With Wax. Another activity, the Crayon Display, is a rotating wheel that contains several materials used to make crayons such as wax, pigment, and label paper. Close by, the Rotational Ball Mold sits on the floor. The Rotational Ball Mold is a large, metal industrial mold that is half open and contains several playground balls. If families visit the Pellet Wall, they can touch the plastic pellets used in the injection molding process through a screen. The wall also contains multi-colored LEGO blocks, an object made from plastic pellets. Another wall, the Molded Artifacts Wall, is a series of shelves that display molded objects such as Gummi Bears, Barbies, a pink lawn flamingo, and PEZ containers. Finally, a Molding Video Wall plays two videos from Mister Rogers' Factory Tours on a continuous loop: How People Make Crayons and How People Make Balls. A variety of different crayons and inflated play balls surround the video screen.

Figure 4. Images from the Molding Area of the How People Make Things exhibition:

a.) Molding Video and Rotational Ball Mold, b.) Molding With Wax and the Pellet Wall, c.) Fill-A-Mold and the Crayon Display, d.) Mold Matching

The third room of the exhibition is the Cutting Area. The Cutting Area activities focus on the idea that cutting is a process in which material is cut away or removed using a sharp-edged tool to make a new shape. Exhibit experiences in this area include Cutting With Wax, the

Three-Axis Mill, Die Cut a Box/Horse, the Baseball Glove Display, the Scrap Wall, the Cut Artifacts Wall, and Cutting Videos. In Cutting With Wax, families sit at a grated table with six rotating blocks of wax attached to the surface. Parents and children use various looped hand tools to shave strips of wax from the blocks. This activity is paired with a machine called the Three-Axis Mill. To use the Three-Axis Mill, parents and children turn one of three handles to move a drill bit up and down or a wax block back and forth and left to right in order to cut into the wax. Another activity in this space, Die Cut a Box/Horse, provides visitors with detailed instructions on how to transform a flat piece of paper into a 3-D object. Here, visitors place paper on the surface of a die (i.e. a foam board with metal blades outlining a horse or box shape), turn a crank to send the die through a set of rollers, remove the cut pieces, and put together their paper box or horse. The Baseball Glove Display is simply a wall arrangement of cut leather pieces, dies used to cut those pieces, and fully assembled baseball gloves. The Scrap Wall is an enclosed wall of curly scrap metal that was removed during the process of making pots and pans. The Cut Artifacts Wall is shelving that holds cut objects including a pop-up book, kazoos, playing cards, and dice. Finally, the Cutting Video Wall plays two videos from Mister Rogers' Factory Tours on a continuous loop: How People Make Shoes and How People Make Carousel Horses. A full-size carousel horse and several pairs of blue shoes surround the video screen.

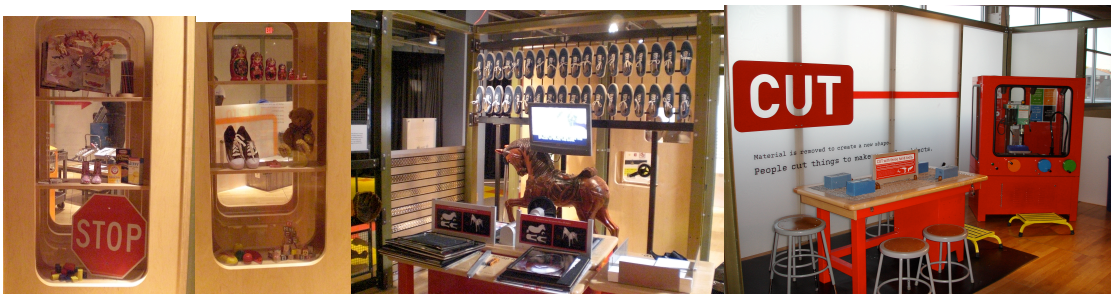

Figure 5. Images from the Cutting Area of the How People Make Things exhibition:

a.) Cutting Artifact Wall, b.) Die Cut a Horse and Cutting Video Wall, c.) Cutting With Wax and the Three-Axis Mill

The fourth room in the exhibition is the Deforming Area. Activities in this area were created to convey the idea that deformation is a process in which a material is changed using force in order to make a new shape. The Deforming Area contains six activities: Vacuum Forces, the Cup Wall, the Rolling Mills and Toggle Press, Deform a Wire, the Deforming Artifact Wall, and the Deforming Video Wall. In the Vacuum Forces activity, families place their hands or foam shapes under a plastic sheet, press a button, and watch as a vacuum sucks the plastic down around their hands or the shapes. The Cup Wall is an enclosed wall of vacuum formed ice cream cups. For the Rolling Mills and Toggle Press, parents and children place a penny in a slot and turn a crank or pull a lever. When the penny shoots out of the mill or press, it has been flattened and textured. In Deform a Wire, visitors place plastic twist ties into a slot, and turn a crank to coil the tie into a spring shape. The Deforming Artifact Wall is a series of shelves containing deformed objects like whisks, a violin, a Slinky, and a muffin tin. Finally, the Deforming Video Wall plays two videos from Mister Rogers' Factory Tours on a continuous loop: How People Make Wagons and How People Make Quarters. A number of small red wagons and state quarters surround the video screen.

Figure 6. Images from the Deforming Area of the How People Make Things exhibition:

a.) Vacuum Forces, Cup Wall, and Deform A Wire, b.) Deforming Artifact Wall, c.) Rolling Mills and Toggle Press

The fifth room is the Assembly Area. This room focuses on the process of joining, fastening, or connecting parts to make a finished product. The Assembly area includes the

following activities: Assemble a Trolley, the Robot Arm, Assemble a Vehicle, the Assembly Artifact Wall, and the Assembly Video Wall. In Assemble a Trolley, families take wooden trolley parts to a table in order to put the trolley together. When they are finished, they can take their trolley over to a ramp to "test" it. A lever at the end of the track allows the trolley to fall into a bin and be disassembled for the next visitor. The Robot Arm was created as a mechanical comparison to the hands-on Assemble a Trolley activity. The Robot Arm is a small mechanical arm that assembles and disassembles an identical trolley at the push of a button. Another activity, Assemble a Vehicle, allows parents and children to change body panels, wheels, dials, and license plates on a small vehicle frame. The Assembly Artifact Wall contains parts of objects and completely assembled objects such as a clock, a shoe, a flashlight, and a drill. Finally, the Assembly Video Wall plays two videos from Mister Rogers' Factory Tours on a continuous loop: How People Make Stoplights and How People Make Toy Cars. Several full-size stoplights and tubes filled with Matchbox cars surround the video screen.

Figure 7. Images from the Assembly Area of the How People Make Things exhibition:

a.) Assemble a Trolley and Assembly Video Wall, b.) Assemble a Vehicle c.) Robot Arm

3.3.2 Participants

Twenty-nine parent-child pairs from the greater Harrisburg area were recruited via e-mail or from the entrance of the Whitaker Science Center. These family groups were comprised of twelve fathers and seventeen mothers (M=0.59, SD=0.50). Seventeen sons and twelve daughters accompanied their parents (M=0.41, SD=0.50). Specifically, six father-son pairs, six father-daughter pairs, eleven mother-son pairs, and six mother-daughter pairs participated in this study. Participating children were between 7 to 12 years of age (M=8.79, SD=1.590).

Several other types of demographic information were collected from parents in order to get a richer understanding of who the participating families were. Most participating families were part of a two-parent household (90%). A few parent participants were single parents (10%). Families who took part in this study had between one and five children at home (M=2.14, SD=0.79).

3.3.2.1 Family Activities. As a family, parents and children participated in a wide range of activities together. The top three activities that parents reported doing with their children were reading books (55%), watching television (41%), and playing sports together (38%). Other activities parents said that they frequently did with their children included outdoor interests such as hiking, biking, hunting, fishing, ice skating, riding ATVs, working with animals, and playing mini-golf. A few parents also mentioned going to church, school, museums, or on vacation together. Indoor activities parents mentioned doing with their children included pastimes like cooking, eating meals, playing board games, going on the computer, and spending time with other friends and family members.

3.3.2.2 Parent Education Level and Occupation. Most parent participants had a college education (83%), while the rest completed high school (17%) (M=1.59, SD=1.09). Of the

parents with a college education, more than a quarter had attended graduate school (29%). Many parents mentioned attending a few years of college (46%), with some obtaining their Bachelor's degrees (25%).

Parents reported working in a wide range of fields including health care, education, law enforcement, and as reporters, life coaches, managers, social service workers, childcare providers, executives, computer programmers, and messengers (69%). A few parent participants were retired or homemakers (14%). Only a few parents mentioned currently working in jobs related to manufacturing (17%).

3.3.2.3 Interest and Experience in Topic of Manufacturing. Only 27% of adult participants had ever worked in the field of manufacturing before (M=0.28, SD=0.46). Slightly more parents (45%) knew of a family member who had worked in manufacturing. Even more families reported having gone on a tour of a factory in the past (59%).

In terms of their experience making things with their children, many parents (83%) said that they had made an object together before. In addition, parents often watched television shows with their children about how things are made (86%). However, the interest that families had in the topic of manufacturing was about even between those with low interest (52% for parents, 48% for children) and those with high interest (48% for parents, 52% for children). On a scale of 1 to 10, parents reported having an average interest in manufacturing of 6.38 (SD=2.32). Parents reported an average of 6.00 regarding their children's interest in manufacturing (SD=2.20).

3.3.2.4 Museum Familiarity. Although seven families were members of the Whitaker Center, none of the twenty-nine participants had previously been to the How People Make

Things exhibition. In fact, most families (62%)were not frequent museum-goers in general (i.e. they reported visiting museums 0-2 times a year) (M=2.31, SD=0.71).

3.3.3 Materials

3.3.3.1 Joint Activity. First, parents and children worked together to answer a series of interview questions about how everyday objects are made (See Appendix C). The Joint Activity was administered at three different timepoints (before the museum visit, immediately after the museum visit, and two weeks later at home) to assess changes in family learning talk. Materials for this task included four physical objects and a binder with paired pictures of objects. To reduce order effects, the study was counter balanced using three different versions of the Joint Activity, meaning that families looked at different objects and binders at each timepoint. Version A of the Joint Activity included the following physical objects: a greeting card, a ketchup bottle, a pie plate and a picture frame. Version B contained a banister, a toy horseshoe, a plastic egg carton, and eyeglasses. Version C had a leather belt, a chocolate bunny, a metal wall decoration, and an umbrella. Each of the objects in the three versions of the Joint Activity was meant to represent one of the four manufacturing processes (i.e. cutting, molding, deforming, and assembly) highlighted in the How People Make Things exhibition. In all three versions of the Joint Activity, families were handed the object and given the following prompt: "This is an [object]. I'd like you to talk together about how you think that object was made."

In part two of the Joint Activity, families were given a binder with four pairs of objects and asked the following questions: "This is [object #1] and this is [object #2]. Do you think these objects were made in a similar way or a different way? What makes you think so?". Version A of the Joint Activity binders included the following object pairs: a coin tray and a fire helmet, a

salt shaker and a flower pot, a guitar pick and a ring, and a bar of soap and a toy soldier. Version B contained pictures of an ice cube tray and packaging, a pen and a knife, a ruler and the head of a golf club, and a slide and a bath toy. Version C paired a plant container with a coffee cup lid, a lock with a paper clip, a compact disc with a Frisbee, and marbles with a piggy bank. Figure 8 provides example binder images from each of the three versions of the Joint Activity.

Figure 8. Example Images from Part Two of the Joint Activity

Version A: A bar of soap and a toy soldier; Version B: A pen and a dinner knife; Version C: A lock and a paper clip

3.3.3.2 Individual Interview. Next, parents and children were separated in order to assess their individual content understanding (See Appendix D). The Individual Interview was administered at three different timepoints (before the museum visit, immediately after the museum visit, and two weeks later at home). For this task, parents wrote down their answers to a series of questions, whereas children answered the questions verbally. Materials for this task mirrored part two of the Joint Activity: a binder containing four paired pictures of objects. To reduce order effects, the study was counter balanced using three different versions of the Individual Interview, meaning that parents and their children looked at different binders at each timepoint. Version A of the Individual Interviews included the following object pairs: a stapler and a screwdriver, a soda can and a milk bottle, gloves and a plane, and a road sign and a trumpet. Version B contained an ice cream scoop and scissors, a pot and a measuring cup, toothpicks and keys, and gears and a garbage can. Version C paired a tube of lipstick with a fire

extinguisher, a food tray and a fish bowl, a wallet with toy train tracks, and a necklace with a toy police badge. Each of the objects in the three versions of the Individual Interview was meant to represent one of the four manufacturing processes (i.e. cutting, molding, deforming, and assembly) highlighted in the How People Make Things exhibition. In all three versions of the Individual Interview, parents and children were handed a binder, and were asked to answer the following questions: "This is [object #1] and this is [object #2]. Do you think these objects were made in a similar way or a different way? What makes you think so?". Figure 9 provides example binder images from each of the three versions of the Individual Interview.

Figure 9. Example Images from the Individual Interviews

Version A: Toothpicks and keys; Version B: A soda can and milk jugs; Version C: A tube of lipstick and a fire extinguisher

3.3.3.3 Demographic Survey. After completing the Joint Activity and Individual Interview Assessments, parents will be given a survey asking them to write down demographic information about their family (See Appendix B). Information sought on the survey includes parents' occupations, education level, activities they frequently do with their children, and their and their children's interest in and experience with the topic of manufacturing and making things. The survey data will be used to assess whether family demographics contributed to any changes in family learning talk or individual content understanding.

3.3.3.4 Parent Journals. Before leaving the museum, parents were given a packet containing ten journal pages (See Appendix E). Parents were also given the option to write their journal entries down via e-mail. The packet text prompted parents to write down any conversations that they had with their children about how everyday objects are made over the next two weeks on those pages. Parents were asked to provide information regarding where they were, who they were with, and what they were doing when each conversation took place. They were also asked to describe what the conversation was about. The written journals were collected at the end of the home visit.

3.3.3.5 Scavenger Hunt. This activity was an assessment conducted after the home visit Individual Interviews (See Appendix F). In the Scavenger Hunt, families were shown four physical objects (a cereal box container, a game board piece, a metal cookie cutter, and a lightbulb), and asked to find an object in their homes that was made in a similar way. When a family returned with an object from their house, they were asked why they thought that object was made in a similar way. In part two of the Scavenger Hunt, families were asked to find four objects in their homes that represented each of the four making processes: molding, cutting, deforming, and assembly. When the family returned with an object from their house, they were asked why they thought that object was made using the specific manufacturing process. During the Scavenger Hunt, the child member of the pair recorded the interaction on a handheld digital camera.

3.3.4 Procedure

How People Make Things is a travelling exhibition, meaning that the exhibition is only in one location for a limited time. Data collection took place in Harrisburg, PA at the Whittaker Museum and in participants' homes from April 8th, 2009 to June 7, 2009.

3.3.4.1 Recruitment. Most participants were recruited from the entrance of the Whitaker Center For Science and the Arts. Additional participants were recruited from the Whitaker Center's e-mail membership list. Participating families received free admission on the date of the study. If they completed both the museum and the home visit, then families also received a $30 cash card.

Fifty-two families were recruited for the museum portion of the study. Of these, eight families had to be removed because part one of the after-visit joint activity was not administered. Eight additional families were removed from the data set because they had been to the How People Make Things exhibition before. Seven families did not complete the home portion of the study, so they were also removed from the dataset. Therefore, twenty-nine families participated in all aspects of the study.

Once participants arrived at the Whitaker and gave verbal consent, the family was led to a table near the entrance of the How People Make Things exhibition. The nature of the study was explained to the family, and both the parent and the child signed informed consent per University guidelines. Families were asked to wear wireless microphones and were videotaped for the duration of the study.

3.3.4.2 Before Museum Visit. Before families entered the exhibition, they participated in three assessments: a parent-child joint activity, individual interviews, and a parent-completed demographic survey (See Table 1). The first assessment, the Joint Activity, consisted of two

parts (see Appendix C). In part one, parents and children were presented with an everyday object, and asked to talk together about how they thought that object was made. This procedure was done for four different objects, corresponding with the four different manufacturing processes represented in the How People Make Things exhibition. In part two, the family was given a binder with four pairs of object pictures, and asked whether they thought each pair of objects were made in a similar way or a different way. Families were also asked to provide reasons for the answers they provided.

After the family finished both parts of the Joint Activity, the participating parent was asked to turn off his or her microphone, and sit in another location. The parent was given a paper-based Individual Interview containing four sets of pictures with two objects each. Parents were asked whether each pair of objects were made in a similar way or a different way, and to write down reasons for their answers. Once parents finished answering the Individual Interview questions, they filled out a Demographic Survey regarding their prior experience with and interest in manufacturing that also contained answered several questions about the family, in general.

While parents were completing the written Individual Interview, each child in the family pair was asked to provide verbal responses to an identical Individual Interview. The children were videotaped during their individual interviews.

After both parents and their children finished answering the Individual Interview questions, the parent was asked to turn their microphone on again.

3.3.4.2 During Museum Visit. The family was led to the entrance of the exhibition. The family was reminded to talk together during their visit as they normally would. They were also told that the exhibition had five rooms, and to let the researcher know when they had completed

their visit. The family was videotaped during their entire visit to the How People Make Things exhibition.

3.3.4.3 Immediately After Museum Visit. Once the family has completed their visit, they will return to the table with the researcher to engage in the parent-child Joint Activity. At this point, the protocol mirrors the Joint Activity and Individual Interview assessment procedures from before the museum visit. However, different objects and pictures are used. Once the family completed these assessments, the logistics of the home visit were scheduled and parents were given a journal to document family conversations around objects. Parents who opted not to keep a handwritten journal were given instructions for completing the journal via e-mail.

3.3.4.4 In-Between the Museum and the Home Visit. At the conclusion of the museum visit, parents were asked to keep a journal to record any conversations that they had with their children about how everyday objects are made. Parents were prompted to describe these conversations in detail including where they were when the conversations took place, who they were with, and what they were doing. Parents wrote in these journals for the two weeks in-between their museum visit and the home visit (See Appendix E).

3.3.4.5 Home Visit. The home visit consisted of three parts: a parent-child Joint Activity, Individual Interviews, and a Scavenger Hunt activity. Parents and children wore wireless microphones and were videotaped during the entire visit. The first two parts of the home visit mirrored the museum before and after-visit assessments. However, different objects and pictures were used.

After both parents and their children finished their Individual Interviews, the parent was asked to turn their microphone on again. Then, the family was given instructions for completing the Scavenger Hunt, and the child was given a digital camera to record the family interaction

(See Appendix F). The Scavenger Hunt consisted of two parts. During part one of the Scavenger Hunt, families were shown four objects, representing each of the four manufacturing processes highlighted in the How People Make Things exhibition, and asked to find an object in their homes that they thought was made in a similar way. After the family found each object, they returned to their original location and were prompted to explain their choices. In part two of the Scavenger Hunt, families were asked to find four more objects: one made by molding, one made by cutting, one made by deforming, and one made by assembly. When the family had completed this task, they returned to their original location and were asked to justify their choices. At the conclusion of the scavenger hunt, the researcher collected the parent journals, and asked parents if there were any conversations that they had not written down that took place during the previous two weeks. If parents recalled such conversations, they were prompted to provide the same information verbally as they would have in the journals.

3.4 CODING AND ANALYSIS

To look for changes in learning talk and children's individual content understanding, we created a measure of learning conversations that built on other researchers' coding categories for parent-child talk (Eberbach & Crowley, 2005; Hohenstein & Tran, 2007; Sanford, 2009). The goal of this measure was to answer research questions 1 and 2, by comparing the quantity of learning conversations parents and children engaged in before, immediately following, and two weeks after the museum visit using a repeated-measures design (See Table 2).

Family talk during the Joint Activity, Individual Interviews, museum visit, parent journals, and Scavenger Hunt Activity was scored for frequency of use of the four characteristics

of learning conversations. One researcher coded the full dataset, while a second researcher coded 20% of the data in order to establish reliability. Reliability between the two researchers was at or above 85% for all codes. Any coding disagreements were resolved through discussion. Definitions of the four coded characteristics as well as examples from the study assessments are listed below:

Characteristic #1: Use of Content

Mentions of the four processes of manufacturing featured in the How People Make Things exhibition, were coded as "content talk", even when used in vernacular form. A parent or child could only receive each type of content code once per conversational turn, meaning that it was possible for an individual to receive up to four specific process codes in a single conversational turn. When applicable, parent and child conversational contributions were added together to calculate Family Talk.

Cutting Talk: A parent or child received the CUTTING code if they used words like: Cut, chip, carve, shave, scrap, remove, chop, rip, trim, etc. If words like chisel and drill were used as verbs, then they will also be coded.

Example: *Child*: I think it might be made like a baseball bat.

Parent: How's that?

Child: How they just take a strip of wood and then they have this little thing where it turns really fast and then it turns and then it shaves off the parts.

- From Joint Activity, Immediately After Visit, Family #7

Molding Talk: A parent or child received the MOLDING code if they used words like: Mold, inject, fill, sprue, melt, harden into a solid, getting cold/getting hot/getting warm, etc. Family members also received this code if they talk about the two sides of a mold closing, opening, or rotating.

Example: *Child:* Maybe [the ketchup bottle] was molded.

Parent: You think it was molded? Okay. Because look it has some seams on the side here, right? Where it might have been molded. Two halves put together.

- From Joint Activity, Home Visit, Family #14

Deforming Talk: A parent or child received a DEFORMING code if they used words like: Deform, vacuum, bash, bend, suck, twist, straighten, press, flatten, force, stamp, crush, smash, etc.

Example: *Parent:* So, you think, look. You think maybe they took the metal [for the wall decoration], and they set it down on top of a face.

Child: Yeah. I think that's what happened.

Parent: They kind of forced the metal to make the face.

- From Joint Activity, Immediately After Visit, Family #44

Assembly Talk: A parent or child received an ASSEMBLY code if they used words like: Assemble, sew it together, put together/put into/put on/put onto/put the pieces, take it apart/take off, screw on, build, etc.

Example: *Child:* I think this [chocolate bunny] was made from a chocolate factory and they had to carve it together and they had to put different candy together and put the eyes.

- From Joint Activity, Before Visit, Family #51

Total Process Talk: The sum of the Cutting, Molding, Deforming, and Assembly codes.

Characteristic #2: Use of Explanations

Explanations could carry over several conversational turns. Parents and children almost always received an explanation code only after an open-ended question was asked. Eberbach & Crowley's (2005) coding scheme was modified to create the two explanation codes.

Process Explanation – Explains how a phenomena is happening rather than the end product; Provide an account of unfolding events (i.e. describe what is happening)

Example: *Parent:* Yes, but look at this. Remember when you had these, and you had to fold them to make them into shape? I think [the greeting card] was a whole piece, they cut it out to different – to a size, and they folded it, and then they printed the letters on there.

- From Joint Activity, Immediately After Visit, Family #9

Other Explanation: Includes non-process explanations such as causal "why" explanations, and explanations dealing with perceptual, material, or functional features of objects

Example: *Child:* I think they're made in a different way bec – but then – the same way because that [salt shaker] has like – it can hold stuff and that [flower pot] can hold stuff.

Parent: They can both hold things, but cause this is made of glass and that's made of plastic, it probably is made a different way. Okay.

- From Joint Activity, Before Visit, Family #31

Characteristic #3: References to Prior Experience

Similar to Hohenstein and Tran's (2007) "Personal" code, an adult or child received the **Prior Experience** code if they referenced past knowledge (ex. "I remember when I made that in school") or experiences (ex. We have these kind of shoes at our house").

Example: *Parent:* What do you think? I'm thinking maybe [the coin tray] was done like those um – that last thing that we saw at the museum where they basically pulled it down over. It was probably hot and it was pulled down over like a form.

Child: Oh yeah, I remember that. Hmmm.

- From Joint Activity, Home Visit, Family #26

Characteristic #4: Asking Questions

Hohenstein and Tran's (2007) question coding scheme was used to explore the kinds of questions that parents and children asked each other during various activities. Two higher-level categories from their coding scheme were used as organizers:

Open-ended: Promote elaboration on the thinking process or expansion of ideas (ex. why and how questions); Questions that encourage open-ended descriptions of what is being seen or done.

Example: *Parent:* From snake bodies. Hmm. Maybe, huh. How do you think they put that [belt] together?

- From Joint Activity, Before Visit, Family #15

Closed-ended: Yes/no questions, questions that call for a factual answer

Example: *Parent:* You didn't see how they made quarters while you were there?

Child: No.

- From Joint Activity, Home Visit, Family #33

4.0 RESULTS

4.1 FAMILY LEARNING TALK DURING THE MUSEUM VISIT

To make a case for change, the claim that the learning environment being studied was a rich location for learning talk to occur must first be established. Here, we will briefly present descriptive information regarding the presence of the four characteristics of learning conversations in families' during-visit talk. Detailed examples of what families' talk looked and sounded like within the five areas of the How People Make Things exhibition can be found in Appendix G.

During the museum visit, families mentioned manufacturing content an average of 40.83 times (SD= 21.80). They engaged in assembly talk most (M=12.00, SD=9.08), followed by cutting talk (M=11.45, SD=7.39), molding talk (M=10.28, SD=7.61), and deforming talk (M=7.10, SD=4.78). Families used process explanations to describe what they were seeing and doing an average of 21.17 times (SD=8.88), and rarely discussed other types of explanations during their visit (M=1.90, SD=2.35). When we looked at the number of opportunities families had to engage in explanatory content conversations within the exhibition, we found that families engaged in rich explanatory talk around content at about 6.83 exhibit activities (SD=4.01).

We also analyzed the number of questions families asked one another during their exhibition experience. We found that families asked many more closed-ended questions

(M=34.00, SD=20.24) than they did open-ended questions (M=6.14, SD=5.00). In addition, we noticed that families referenced an average of 8.55 prior experiences while visiting the exhibition (SD=7.90). This descriptive information suggests that families were rehearsing learning talk within the museum exhibition. We hypothesized that such talk would increase the amount of learning conversations families' engaged in after the visit and later at home. Therefore, we next examine whether changes in learning talk occurred.

4.2 ASSESSING CHANGES IN LEARNING TALK

One of the main hypotheses of this study is that a shared museum visit can change the amount of learning talk families engage in after the visit. In order to find out if the museum visit does have an effect, we assessed family learning talk (as measured by their conversations during the parent-child joint activity) at three different time points: before the museum visit, immediately after the museum experience, and two weeks later at home. Each parent-child joint activity was coded for four characteristics of learning talk: content mentions, explanations, references to prior experiences, and questions.

If the museum visit had a positive impact on family learning talk, then we would expect there to be a significant increase in the amount of manufacturing content families talked about after their visit and later at home, compared to before their visit. We also predicted a significant increase in the amount of process explanations families gave, and a significant decrease in other types of explanations mentioned both immediately after and two weeks following the museum experience, compared to before the visit. Furthermore, we anticipated that families would reference significantly more prior experiences after the museum visit and at home than they

would before the visit. Our final prediction in terms of amount of learning talk was that families would ask significantly more open-ended questions and significantly less closed-ended questions after their visit and two weeks later than they had before their visit.

Changes in each of the characteristics of learning talk are examined below. Results are reported first for the family unit as a whole, and then explore parents and children's contributions to the joint activity.

4.2.1 Content Mentions

Since this study focuses on an exhibition about how everyday objects are made, content mentions are defined as family talk around key manufacturing process concepts such as cutting, molding, deforming, and assembly. The average amount of Family Content Talk was calculated by adding the parent and child conversational contributions together (see Figure 10).

A repeated-measures ANOVA examining family content talk established a significant effect for timepoint, $F(2,56) = 15.87$, $p < .001$. Pairwise comparisons revealed that families talked more frequently about content immediately after their museum visit ($M = 18.13$, $SD = 9.55$) in comparison to the amount that they talked about content before the museum visit ($M = 10.89$, $SD = 5.59$), $p < .001$, $d = 0.93$. Furthermore, families still talked about content significantly more two weeks after the visit ($M = 21.24$, $SD = 11.45$) than they had been before the visit, $p < .001$, $d = 1.15$.

An examination of parent and child separate conversational contributions showed that the pattern of increasing content talk over time holds. A repeated-measures ANOVA on parent content contributions confirmed a significant effect by timepoint, $F(2,56) = 12.47$, $p < .001$. Specifically, pairwise comparisons indicated that parents' talk significantly more about content immediately after the museum visit ($M=10.93$, $SD=5.32$) than they do before the museum visit

(M=7.28, SD=3.59), p=.003, d= 0.80. Such comparisons also showed that parents talk significantly more about content two weeks later at home (M=12.45, SD=5.96) than they had before the shared museum experience, p<.001, d= 1.05.

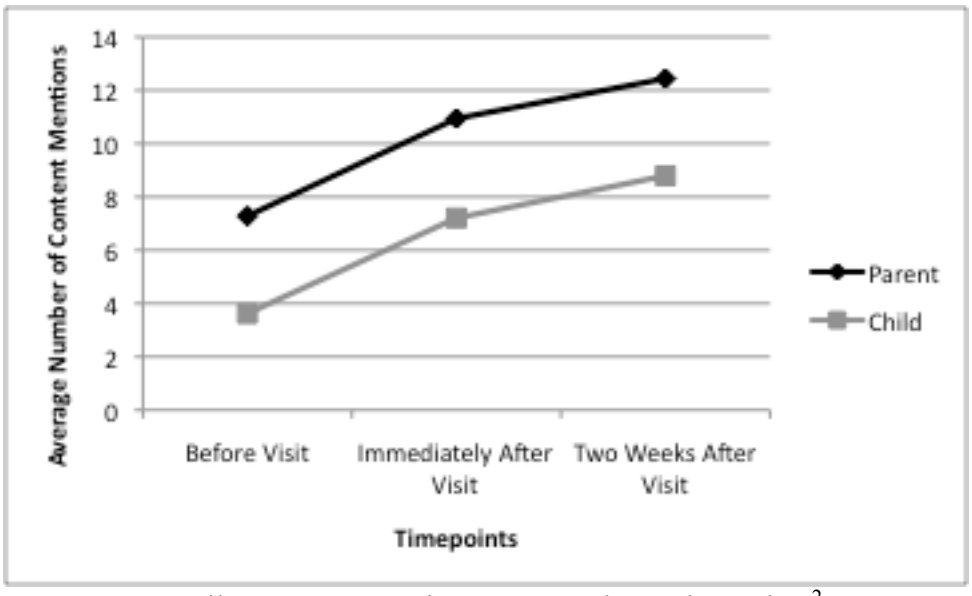

Figure 10. Family Content Mentions Across Three Timepoints[2]

A repeated-measures ANOVA was also conducted looking at children's content talk. This test revealed a significant effect by timepoint, F(2,56) = 12.39, p<.0001. Subsequent pairwise comparisons found that children talk significantly more about content immediately after their visit (M=7.21, SD=6.17) than they do before their visit (M=3.62, SD=3.58), p=.006, d= 0.71. These comparisons also indicated that children engaged in significantly more content talk two weeks after the museum visit (M=8.79, SD=6.97) than they had before the shared experience, p<.001, d= 0.93.

Overall, there is a significant difference in how parents and children talk about content across timepoints. But we wanted to know if there was any variation in how families talked

[2] n = 29 for all joint activity analyses

about particular manufacturing processes before, immediately after, and weeks after their visit. In order to answer this question, the following analysis breaks Content Mentions down into molding talk, cutting talk, deforming talk, and assembly talk.

A series of repeated-measures ANOVAs established that there is a significant effect for timepoint in family's molding talk, $F(2,56) = 10.90$, $p<.001$. There was also a significant effect over time for family's deforming talk, $F(2,56) = 11.71$, $p<.001$. However, timepoint did not have a significant impact on family cutting talk, $F(2,56) =2.90$, $p=.063$. There were also no significant differences with regards to time on family's assembly talk, $F(2,56) = 2.33$, $p=.107$.

Pairwise comparisons indicated that families talked about the process of molding significantly more after their visit than they did before their visit, $p < .001$, $d= 0.89$ (See Table 3). Families also talked about molding significantly more later at home than they had before their shared museum experience, $p < .001$, $d= 0.89$. In addition, pairwise comparisons show that families talked about the process of cutting significantly more two weeks later at home than they had before their visit, $p =.046$, $d= 0.49$. Furthermore, the process of deforming was discussed significantly more immediately after the visit than it had been before the visit, $p=.002$, $d= 0.74$. Two weeks later, families still talked about the deformation process more than they had before the museum experience, $p <.001$, $d= 1.21$. Pairwise comparisons also showed that the process of assembly was mentioned more at home than it had been immediately after the visit, $p=.05$, $d= 0.43$.

Looking solely at parent contributions to specific process talk, parent talk sometimes followed the overall family pattern, and sometimes it did not. Similar to the pattern of overall family process talk, parents' talk about molding was significant by timepoint, $F(2,56) = 7.29$, $p=.002$. The pattern also held for parent deforming talk over time, $F(2,56)=9.05$, $p<.001$. A

repeated-measures ANOVA revealed no significant differences in parent cutting talk with regards to time, F(2,56) =2.69, p=.077. Parent assembly talk over time was also not significant, F(2,56) =1.66, p=.199.

Table 3. Average Family Specific Process Mentions at Three Different Timepoints

	Before Visit	**Immediately After Visit**	**Two Weeks Later At Home**
Molding Talk	4.38 (3.90)	8.62 (5.45)	9.14 (6.47)
Cutting Talk	2.66 (2.32)	3.97 (3.11)	4.14 (3.59)
Deforming Talk	1.21 (1.32)	3.00 (3.15)	4.21 (3.25)
Assembly Talk	2.66 (1.84)	2.55 (2.23)	3.76 (3.26)

Note: Tables report mean content mentions with standard deviations in parentheses

Pairwise comparisons clarified that parents talked about the process of molding significantly more after their visit (M=5.21, SD=2.97) than they had before their visit (M=3.07, SD=2.48), p =.004, d= 0.78. Parents also talked more about molding two weeks later at home (M=5.34, SD=3.29) than they did before the museum experience, p = .002, d= 0.78. In addition, parents discussed the process of deforming significantly more immediately after the visit (M=2.00, SD=2.20) than they had been before the visit (M=0.92, SD=1.07), p =.006, d= 0.62. Pairwise comparisons indicated that parents still talked about deformation significantly more two weeks after the visit (M=2.79, SD=2.66) than they had before the museum experience, p <.001, d= 0.92. Unlike the overall pattern of family process talk, parents referenced the process of cutting significantly more immediately after their visit (M=2.21, SD=1.52) than they did before their visit (M=1.45, SD=1.33), p =.044, d= 0.53.

Turning now to children's contributions to their family's specific process talk, we see that children's talk tended to follow the overall family pattern, but still varied in some instances. Mirroring the pattern of overall family process talk, children's molding talk was significantly

impacted by timepoint, F(2,56) =8.26, p=.001. Children's deforming talk also increased significantly over time, F(2,56) =6.12, p=.008. There were no significant differences in the amount of children's cutting talk over time, F(2,56) =1.86, p=.165. There were also no significant differences in children's assembly talk across the three timepoints, F(2,56) =2.26, p=.114.

However, pairwise comparisons supplied evidence that children used specific process talk slightly differently than adults. Like their parents, children engaged in molding talk significantly more immediately after their visit (M=3.41, SD=3.78) than they had before their visit (M=1.31, SD=1.89), p=.001, d= 0.70. Children also talked significantly more about molding at home (M=3.79, SD=3.79) than they had before their visit, p<.001, d= 0.83. In addition, children mentioned the process of deforming significantly more immediately after the visit (M=1.00, SD=1.44) than they had been before the visit (M=0.28, SD=.59), p=.022, d= 0.65. This result was sustained two weeks later at home (M=1.41, SD=1.57) when compared to children's deforming talk before the museum experience, p<.001, d= 0.95. Unlike adults, there were no significant pairwise comparisons for children regarding the process of cutting.

Taken together, these results support our claim that the museum experience increases family learning talk as evidenced by their content mentions.

4.2.2 Explanations

For this study, explanations were separated into two types: Process Explanations and Other Explanations. Process explanations are reasons provided by the parent or child that focus on learning and include content as well as other talk outlining the steps needed to make an everyday object. Other explanations are justifications that do not focus on learning and include talk about the superficial, functional, and material features of objects. Because explanations are often built

collaboratively, a single explanation was frequently coded across several conversational turns, with the parent and child each getting credit for their participation. The average amount of Family Process Explanations was calculated by adding the parent and child conversational contributions together (see Figure 11).

A Repeated-measures ANOVA showed that, overall, families increased the amount of process explanations they gave across timepoints, $F(2,56)= 10.84$, $p<.001$. Pairwise comparisons indicated that families provided more process explanations two weeks after their visit ($M = 13.18$, $SD = 5.458$) than they had been before their museum visit ($M = 9.38$, $SD = 4.118$), $p<.001$, $d= 0.79$. In fact, families also gave more process explanations at home than they had immediately after the museum visit ($M = 10.48$, $SD = 2.947$), $p=.006$, $d= 0.62$.

Examining parent and child contributions separately, we find that the pattern is identical to that of family process explanations. Parents gave significantly more process explanations over time, $F(2,56)= 7.32$, $p=.001$. Children also provided significantly more process explanations over time, $F(2,56)= 7.32$, $p=.002$. Specifically, parents gave significantly more process explanations at home ($M=6.59$, $SD=2.35$) than they did before the museum visit ($M=4.72$, $SD=2.46$), $p=.002$, $d= 0.78$. Parents also gave more process explanations at home than they had immediately after the museum visit ($M=5.41$, $SD=1.84$), $p=.018$, $d= 0.56$. Similarly, children used significantly more process explanations two weeks later ($M=6.59$, $SD=4.30$) than they had before their visit ($M=4.66$, $SD=3.34$), $p=.001$, $d= 0.50$. Children also gave more process explanations at home than they had immediately after their visit ($M=5.07$, $SD=2.73$), $p=.017$, $d= 0.42$.

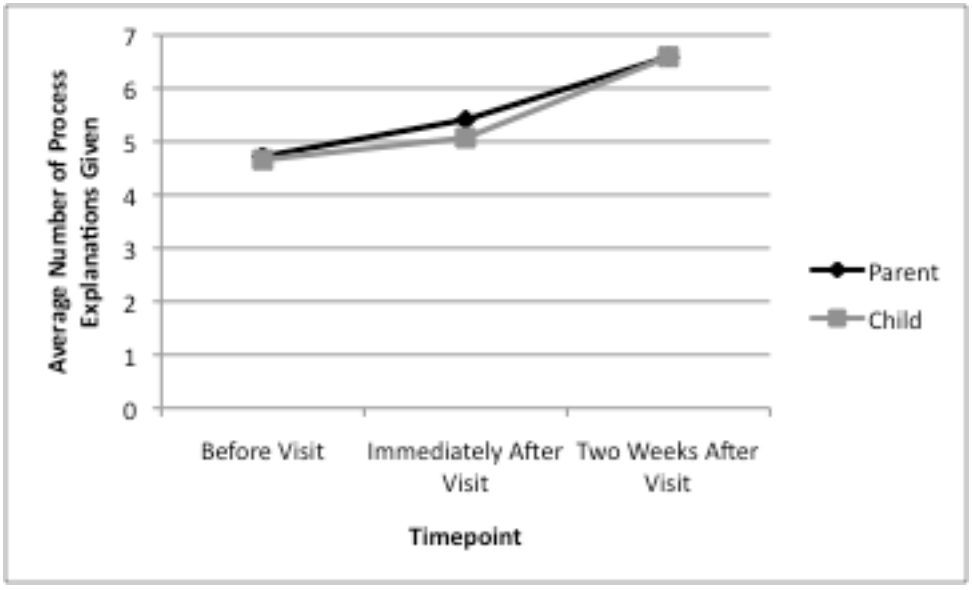

Figure 11. Family Process Explanations Across Three Timepoints

Considering other non-process explanations that families gave, we see that the amount of other explanations given significantly decreased over time, $F(2,56)= 10.08$, $p<.001$. Overall, families provided significantly less other types of explanations immediately after their visit ($M = 3.65$ $SD = 2.468$) than they had before the museum visit ($M = 6.24$, $SD = 3.934$), $p<.001$, $d= 0.79$. In fact, families were also significantly less likely to give other types of explanations at home ($M = 3.83$, $SD = 1.56$) than they had before their visit, $p=.003$, $d= 0.81$.

The above pattern holds when we consider parents and children separately. Both parents and children provide less other types of explanations over time, $F(2,56)= 8.34$, $p=.001$, and $F(2,56)= 4.25$, $p=.031$, respectively. Pairwise analyses identify parents immediately after the visit as giving significantly less other explanations ($M=0.93$, $SD=1.19$) than they do before the museum visit ($M=2.34$, $SD=1.95$), $p=.001$, $d= 0.87$. Parents also gave significantly less other types of explanations at home ($M=1.31$, $SD=1.29$) than they had before the museum experience, $p=.006$, $d= 0.62$. Similarly, children use significantly less other types of explanations to

describe how everyday objects are made immediately after the visit (M=2.72, SD=2.00) than they do before their visit (M=3.90, SD=3.26), p=.020, d= 0.44. Children also gave significantly less other types of explanations two weeks later at home (M=2.52, SD=0.79) than they had before their museum experience, p=.039, d= 0.58.

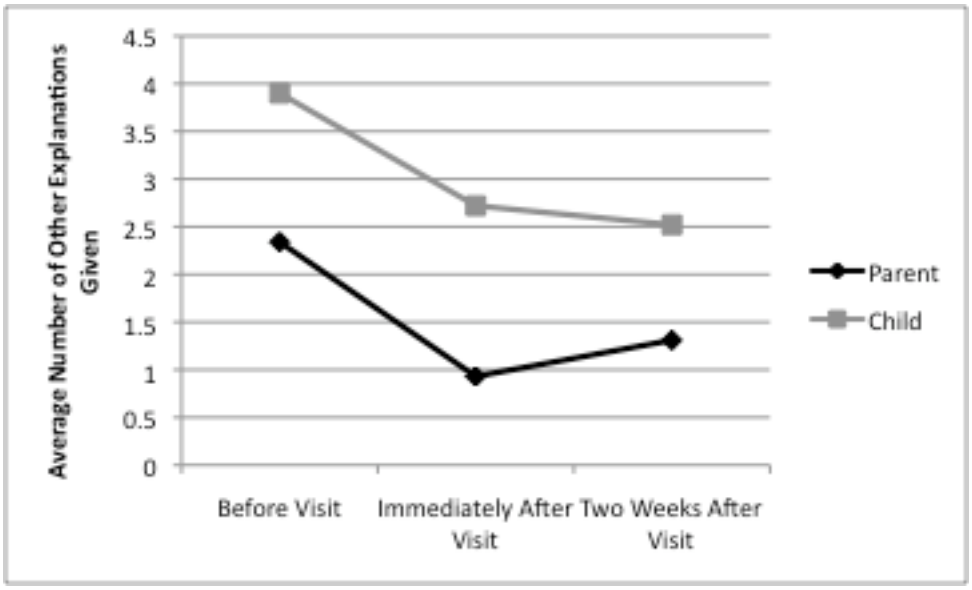

Figure 12. Other Family Explanations Across Three Timepoints

Taken together, these findings represent converging evidence that as families moved away from other types of explanations, the amount of process explanations they gave to one another increased significantly over time.

4.2.3 References to Prior Experiences

Prior experience mentions were defined as references to shared past experiences regarding a particular location, person, or object. The average amount of Family Prior Experience Mentions was calculated by adding the parent and child conversational contributions together (see Figure 13).

A repeated-measures ANOVA found that families referenced prior experiences more frequently over time, $F(2,56)= 9.32$, $p<.001$. Pairwise comparisons showed that families referenced significantly more prior experiences immediately after their museum visit ($M = 5.07$, $SD = 3.595$) than they had before the museum visit ($M = 2.45$, $SD = 2.613$), $p<.001$, $d= 0.83$. However, families provided significantly less prior experience references two weeks later at home ($M = 3.24$, $SD = 2.837$) than they had immediately after the museum visit, $p=.020$, $d= 0.57$.

When parent and child contributions are analyzed separately, the pattern is identical to the overall family pattern for parents, but not for children. A repeated-measures ANOVA of parent prior experience mentions reveals a significant effect for timepoint, $F(2,56)= 9.63$, $p<.001$. However, a repeated-measures ANOVA of children's prior experience mentions shows no significant differences across timepoint, $F(2,56)= 1.37$, $p=.263$. A pairwise comparison of parent prior experience mentions found that parents gave significantly more references to past experiences immediately after the museum visit ($M=3.97$, $SD=2.60$) than they did before the museum visit ($M=1.79$, $SD=2.21$), $p<.001$, $d= 0.90$. Yet parents provided significantly less references to prior experiences two weeks later at home ($M=2.48$, $SD=2.49$) than they had immediately after the museum visit, $p=.014$, $d= 0.59$.

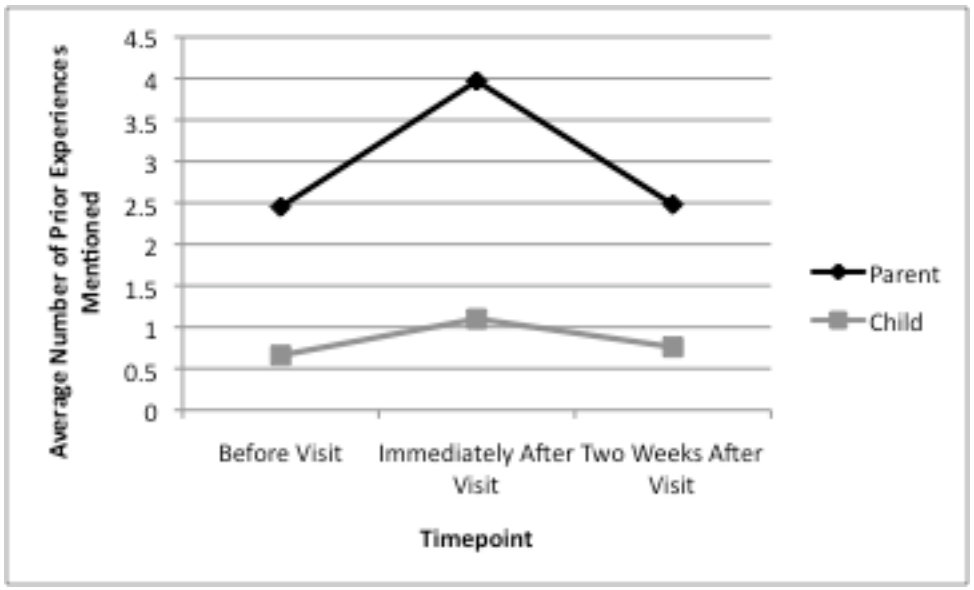

Figure 13. Family Prior Experience Mentions Across Three Timepoints

Since families had just finished walking through the exhibition, it is not surprising that there was a sharp increase in the amount of prior references parents gave their children. However, it is important to recognize that immediately after the visit, families were making connections to the exhibition's contents when talking together about how everyday objects are made. The increase in links to prior experiences is evidence that parents were trying to use the exhibition as a reference point for their kids. It is also interesting to note that that the number of prior experience mentions families' gave two weeks after the museum experience was similar to the amount of references they gave before the visit, suggesting that exhibit references are more often used in close proximity to the shared family event.

4.2.4 Questions

Questions were divided into two types: Open-ended questions and closed-ended questions. Open-ended questions were defined as "how" and "why" queries that required a thoughtful response. Closed-ended questions were classified as yes/no inquiries or questions that sought a

short, fact-based response. The average amount of family open and closed-ended questions was calculated by adding the parent and child conversational contributions together (see Figures 14 & 15).

A repeated-measures ANOVA of families' open-ended questions asked over time showed a significant effect by timepoint, $F(2,56)= 3.87, p= .039$. Pairwise analyses indicate that families' use of open-ended questions drops significantly from before the museum visit ($M = 6.17$, $SD = 3.761$) to immediately after the visit ($M = 4.55$, $SD = 3.823$), $p=.006$, $d= 0.43$. Yet the amount of open-ended questions asked by families raises significantly two weeks after the museum visit ($M = 6.07$, $SD = 5.509$) compared to immediately after the visit, $p=.012$, $d= 0.32$.

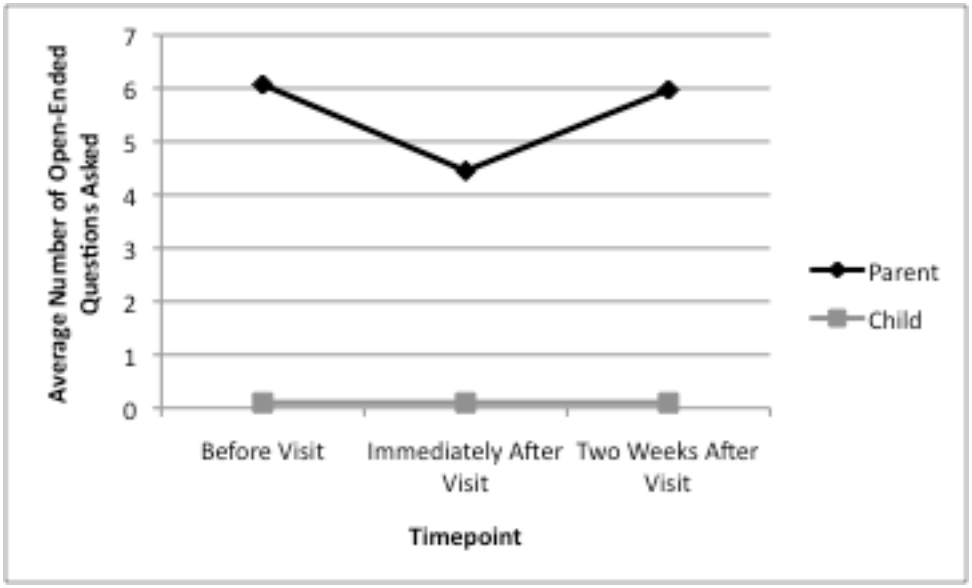

Figure 14. Family Open-Ended Questions Across Three Timepoints

When parent and child contributions are looked at separately, the pattern is identical to the larger family pattern for parents, but not for children. This result is not surprising because children asked very few questions overall. A repeated-measures ANOVA of parent open-ended questions indicated a significant effect for timepoint, $F(2,56)= 4.07$, $p=.036$. As expected, a

repeated-measures ANOVA of children's open-ended questions showed no significant differences across timepoint, $F(2,56)= 0.00$, $p= 1.00$.

A pairwise comparison of parent open-ended questions found that parents asked significantly less open-ended questions immediately after the museum visit ($M=4.45$, $SD=3.80$) than they had before the museum visit ($M=6.07$, $SD=3.65$), $p=003$, $d= 0.43$. However, parents asked significantly more open-ended questions two weeks after the visit ($M=5.97$, $SD=5.45$) than they had immediately after the museum experience, $p=.011$, $d= 0.32$.

Turning to the average amount of closed-ended questions families asked, we see that there is a significant effect for timepoint, $F(2,56)= 4.76$, $p= .012$. Pairwise analyses indicate that families' use of closed-ended questions drops significantly from before the museum visit ($M = 17.52$, $SD = 10.878$) to immediately after the visit ($M = 12.72$, $SD = 9.180$), $p=.010$, $d= 0.48$. In contrast, the amount of closed-ended questions asked by families raises significantly two weeks after the museum visit ($M = 14.34$, $SD = 10.434$) compared to immediately after the visit, $p=.049$, $d= 0.16$.

When parent and child contributions are looked at separately, the pattern is again identical to the larger family pattern for parents, but not for children. A repeated-measures ANOVA of parents' closed-ended questions indicates a significant effect for timepoint, $F(2,56)= 5.661$, $p=.006$. A repeated-measures ANOVA of children's closed-ended questions shows no significant differences across timepoint, $F(2,56)= 1.396$, $p= .256$.

Pairwise comparisons of parents' closed-ended questions revealed that parents asked significantly less closed-ended questions immediately after the museum visit ($M=11.86$, $SD=9.29$) than they had before the museum visit ($M=16.83$, $SD=10.72$), $p=006$, $d= 0.50$. As with open-ended questions, parents asked significantly more closed-ended questions two weeks after

the visit (M=13.45, SD=10.47) than they had immediately after the museum experience, p=.027, d= 0.16.

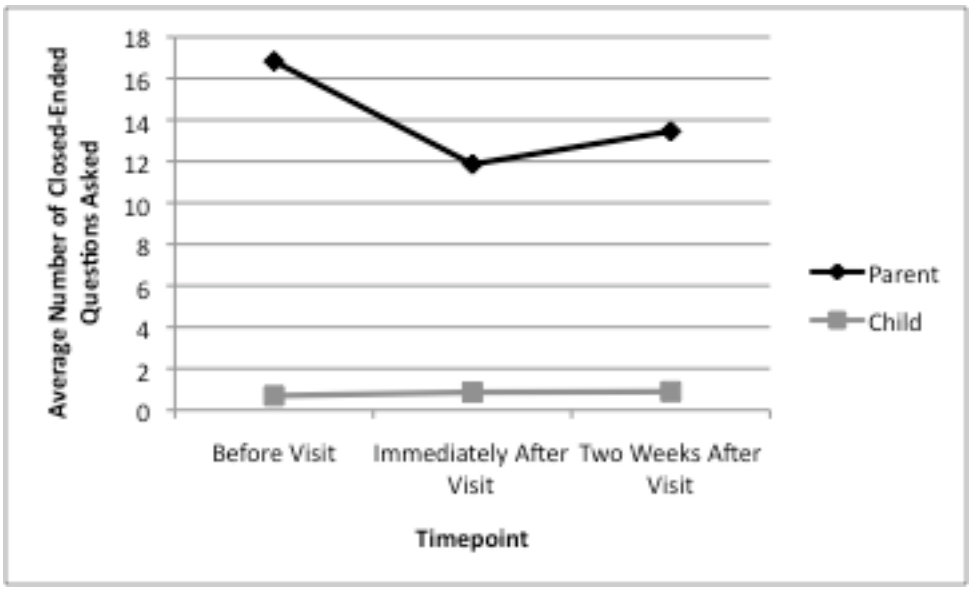

Figure 15. Family Closed-Ended Questions Across Three Timepoints

As expected, parents asked the majority of questions during family conversations. Yet unlike other characteristics of learning talk, the amount of questions families asked decreased after the museum visit. This result does not necessarily mean that the exhibition was a difficult place for families to ask questions. Logically, it was possible for families to learn a general question-asking strategy during their museum visit in addition to engaging in more explanatory process talk or mentioning more manufacturing content in their conversations because the exhibition afforded families opportunities to do both. For this set of families, it just did not happen. Open-ended questions are only one way to get children involved in the conversation. Before the museum visit, participating families used questions to elicit their children's ideas regarding how everyday objects are made. After the museum visit, families had more content

knowledge to draw from, so they may have needed to ask less questions in order to keep the conversation going.

4.3 EXTENDING LEARNING CONVERSATIONS AROUND OBJECTS INTO THE HOME ENVIRONMENT

Having established through the joint activity assessments that changes in family learning talk did occur, we now turn to data collected from the parent journals and scavenger hunt activity as a window into families' more naturalistic conversational practices. Both the parent journals and the scavenger hunt activity contextualize what changes in family talk at home looked and sounded like. We first look within parents' journal entries to see the variety of opportunities families found to talk about everyday objects once they left the museum. Then, we examine family conversations during the scavenger hunt activity to hear what learning conversations at home can sound like.

4.3.1 Describing Family Conversations At Home Using Parents' Self-reports

Recall that we asked parents to write down any conversations that they had with their children about how everyday objects are made for the period after the museum visit until the home visit two weeks later. Parents' journal entries were examined for mentions of content talk, process explanations, prior references, and open-ended questions as well as for details about the situations during which these conversations took place.

On average, parents reported having 2.17 conversations with their children about how everyday objects are made during the two weeks in between the museum visit and the home visit (Range= 0-12; SD=2.80). Of these, eighty-eight percent of the journal entries described conversations around content, linking manufacturing processes to an everyday object (M=1.90, SD=4.85). In particular, parents' journal entries mentioned the assembly process most (38%), followed by molding (31%), deforming (16%), and cutting (15%).

According to the journals, seventy-five percent of families' conversations around objects involved explanatory process talk (M=1.62, SD=2.31). Forty-five percent of families' talk dealt with the materials that objects were made from, the physical properties of those objects, and the mechanisms that made the objects function properly (M=0.97, SD=1.18). In addition, families were using references to prior experiences to contextualize their object talk (M=1.03, SD=2.37). In terms of parents' self-reported use of questions, 45% of families object conversations involved asking open-ended questions (M=0.97, SD=2.03) and 40% included closed-ended questions (M=0.86, SD=2.53). In sum, although the quantity of conversations that families were having about everyday objects was small, families were having quality conversations that incorporated rich learning talk.

We also wanted to know where families were having these conversations, what they were doing when the conversations took place, and what kinds of objects triggered families to talk together. Most family conversations around objects occurred at home (68%) in places like the dining room, the kitchen, the living room, hallways, the backyard and even the laundry room. Several conversations took place outside of the home (32%) in locations like restaurants and stores, in the car, at school, on a train, and at a local baseball field. Explanatory talk about objects took place during a wide range of activities including preparing meals, jumping on a

trampoline, driving across bridges, watching television, doing crafts, and shopping for sporting goods. Some of the objects that families talked about together include napkins, terracotta pots, telephone poles, soapbox cars, light switches, swingsets, brass instruments, water bottles, wine corks, surfboards, pancakes, and doll clothes.

The following are some excerpts from parent journals, which demonstrate how opportunities to talk about objects arose during everyday situations:

> "We were at a sandwich shop for lunch today and I saw the plastic forks. I asked the kids if they remembered how the forks were made. They all remembered the plastic spoons being made by melting down plastic pellets and pouring it into a mold." - Participant #5 (Entry 1 of 2)

> "We were driving to church when Ellen, out of the blue, commented that our van had a lot of pieces…I asked her how all the little pieces get put together. She said, 'Like how Amy made the trolley at the Whitaker Center.'"
>
> – Participant #44 (Entry 1 of 4)

> "While watching Mister Rogers' Neighborhood, I said to the children, 'We know how that trolley is made. Who can remember?' They responded, 'By putting it all together.' I asked Sydney what that process is called. She said, 'Assembly.' On the show they visited a school bus. I then asked how they thought the bus was made. They answered, 'The same way. By the assembly process.'"
>
> – Participant #46 (Entry 4 of 12)

> "We were at Blue Ribbon Dairy getting ice cream. Jane said, 'Hey, Mom! Look at the ice cream cone. It has those lines on it like the things from the molds.'"
>
> - Participant #37 (Entry 1 of 4)

> "Bri and I were talking in the laundry room about a liquid detergent container molded with a clear strip on the side to show the level of product in the container. The rest of the bottle is green. I asked her how they could make the clear strip on the edge, surrounded by green. She thought the clear strip would be build into the inside of the bottle. She saw the lines on the side and thought it was from the plastic mold process." - Participant #6 (Entry 8 of 8)

The excerpts above demonstrate that family learning conversations can happen in a variety of settings during a wide range of activities. The journal entries show that families were using encounters with everyday objects as additional opportunities to practice talking together about how things are made. We would hypothesize that families who had more of these conversations would perform better on the subsequent home-based post-test.

4.3.2 Describing Family Conversations At Home Through the Scavenger Hunt Activity

In this section, we examine families' talk during the scavenger hunt activity to further describe the nature of family learning conversations around everyday objects at home. Family talk during the scavenger hunt activity was analyzed for the presence of the four characteristics of learning talk: content talk, process explanations, prior references, and open-ended questions.

During the scavenger hunt activity, families talked about manufacturing content an average of 31.5 times (SD= 15.03). Of these content mentions, families referred to the molding process most (M=9.31, SD=5.73), followed by the cutting (M=8.14, SD=5.58), assembly (M=7.41, SD=3.91), and deforming processes (M=6.66, M=5.18). Families used process explanations to describe how everyday objects in their homes were made an average of 15.2 times (SD=5.95). In addition, families' conversations during the scavenger hunt referenced prior experiences an average of 2.69 times (SD= 3.18). Families also asked an average of 3.34 open-ended questions (SD=5.09) to one another while participating in the scavenger hunt. Taken together, these numbers suggest that activities around everyday objects within families' homes had the potential to elicit a great deal of learning talk.

The following examples illustrate the kinds of conversations families had at home. The first excerpt is from a conversation between a mother and her seven year-old daughter, Kellan[3] during the first part of the scavenger hunt activity. Here, the researcher hands the family a metal, heart-shaped cookie cutter, and asks them to look for an object in their house that they think was made in a similar way:

> *Mother:* So, Kellan. What are you looking for? How was the cookie cutter made do you think?
>
> *Kellan:* It's cut out. Die cut.
>
> *Mother:* You think it's die cut? So and then it's just die cut and then –Think about this, Honey. It's a piece of what?
>
> *Kellan:* Metal.

[3] All participants' names are pseudonyms.

Mother: And it would be cut to a certain shape, but then what would have to happen to it?

Kellan: Heated.

Mother: And what?

Kellan: Bent.

Mother: So that's a what process?

Kellan: Deformed.

Mother: Okay. What do you want to get?

Kellan: Monster truck.

Mother: No, what do you want to get that's something that starts out in one shape but becomes another by – usually by bending. What have you been playing with? Last week down the stairs?

Kellan: Slinky.

Mother: You think that was kind of made like this. Now this [Slinky]'s much more than the [cookie cutter]. The other one's just a little bit bent.

-Family #46, Scavenger Hunt Activity

Kellan's mother begins the exchange with an open-ended question. Kellan responds using manufacturing terminology highlighted in the exhibition, words like "die cut" and "deform". The family also uses more colloquial terms like "bend". Kellan's mother uses both kinds of content to help her daughter construct an explanation of the process of making a cookie cutter. Once the family has established the process, Kellan's mother encourages her to daughter to think of an object that was made in a similar way. At first, Kellan just chooses an object

nearby, but her mother references a prior experience her daughter had in order to assist Kellan in finding a similarly made object. The conversation winds down with Kellan's mother making one final comparison between the object from their house and the cookie cutter.

The second selection is from a father and his 12 year-old son, Blake, who have finished the second part of the scavenger hunt in which they were asked to bring back four items: one made by cutting, one made by assembly, one made by deforming, and one made by molding:

Father: All right. All right. Let's see. Cutting.

Blake: We think that's cutting.

Father: Now when we were thinking cutting, we were thinking that it could still be cut from something and then formed into like, in this case, a box. It was cut out in the shape and then it was basically –

Blake: Remember the cutting like to make a box at the museum?

Father: Yeah. So that's what we were thinking here cause that was our – that was our thing for cutting.

Blake: Okay. This [PVC pipe] we're thinking is forming [molding].

Father: We think that that came from, like, the beads and was basically turned into a liquid and then -

Blake: It was melted and then it – they let it harden into its shape.

Father: Around a form and it comes out in – we were thinking it probably comes out in longer –obviously longer. I know it comes longer than that, but it comes out in longer sheets ,then cut to length, and stamped, and all that kind of stuff.

Researcher: Is that like a PVC pipe?

Father: Yeah. Yeah. Piece of PVC pipe. Um, and then for assembly we were thinking that the doorknob.

Researcher: Okay.

Father: The doorknob because obviously it's made of multiple pieces and then put together.

Blake: We think the [packaging] is deform.

Father: And we were – I won't say we were in debate, but what we were thinking on the deform was the um –

Blake: The actual like plastic.

Father: The ones where they pulled it over as opposed to like being pressed or stamped. It was something that was pulled down over. Um, kind of like an egg carton in my mind, or something that this was probably made in a fashion like that. This container for the doorknob. So, that was our – that was our deformed.

-Family #26, Scavenger Hunt Activity

In the excerpt above, Blake and his father take turns building up explanations of how each of the objects from their house were made. In doing so, they reference two prior experiences: the die cut box from the museum visit and the egg carton from a prior joint activity assessment. The family does not use any open-ended questions during their talk. Instead, they seem to utilize the other three characteristics of learning conversations: content talk, process explanations, and prior experiences to talk together about the objects in their home. Thus, family talk at home, as evidenced by the Scavenger Hunt Activity, is consistent with changes in learning talk over time.

4.4 ARE CHANGES IN LEARNING TALK THE EFFECT OF THE SHARED MUSEUM EXPERIENCE OR AN ARTIFACT OF REPEATED QUESTIONING?

In order to test our claim that rehearsal of family learning talk in a museum setting can affect what families talk about afterwards, we now explore the extent to which patterns of change can be linked to differences in families' conversations within the exhibition and at home. We ran a series of regressions to test a model that could account for changes in families' talk, and find possible correlations between family talk and activity. (See Figure 17). In the model, families' learning conversations are represented by their shared content talk. A correlation matrix of all of the variables that were entered into the model can be found in Figure 16. The means and standard deviations for each of the variables in the model have appeared previously in sections 4.2, 4.3, and 3.3.2.

Six regression equations were calculated to create the model (See Appendix I). The first regression looked at factors that might predict families' before-visit content talk. Demographic predictors that were analyzed included parent gender, child gender, child age, parent education level, parent manufacturing experience, parent manufacturing content interest, child manufacturing content interest, and families' familiarity with visiting museums. Only parents' manufacturing content interest significantly predicted the amount that families talked about content before their museum visit, R^2 =.316, F(1,27) = 12.47, p=.002. In particular, families with parents who self-reported high interest in the topic of manufacturing talked significantly more about content before their visit than families in which parents reported low interest in manufacturing topics.

	Parent Gender	Child Gender	Child Age	Families' Familiarity With Museums	Parent Topic Interest	Child Topic Interest	Parent Education Level	Parent Manufacturing Experience	Families' Before Visit Content Talk	Families' After Visit Content Talk	Familes' Content Conversations In-Between Visits	Families' During Visit Explanatory Content Conversations	Families' Content Talk At Home	Families' Content Talk During the Scavenger Hunt
Parent Gender	1													
Child Gender	-.15	1												
Child Age	.02	-.29	1											
Families' Familiarity With Museums	.07	-.27	.31	1										
Parent Topic Interest	-.38*	.11	.32	.03	1									
Child Topic Interest	.32	-.39*	.16	.27	-.06	1								
Parent Education Level	.20	-.13	.07	.22	.01	.28	1							
Parent Manufacturing Experience	-.42*	.27	.03	-.05	.17	-.46*	-.34	1						
Families' Before Visit Content Talk	-.35	.07	.43*	.22	.56**	.02	.03	.05	1					
Families' After Visit Content Talk	-.03	-.03	.46*	-.01	.15	.08	.09	-.07	.36	1				
Families' Content Conversations In-Between Visits	.09	.37*	-.23	.13	.18	.11	.18	.01	.25	.26	1			
Famiies' During Visit Explanatory Content Conversations	-.09	.04	.19	-.23	-.09	-.30	-.19	.22	.12	.46*	.10	1		
Families' Content Talk At Home	.09	.04	.06	.25	.11	.19	.21	-.01	.39*	.19	.46*	.51**	1	
Families' Content Talk During the Scavenger Hunt	-.35	-.03	.27	.20	.24	.09	.15	-.03	.40*	.52**	.10	.06	.47**	1

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed);

Figure 16. Correlation Matrix for Variables in Model of Family Content Talk

A second regression was run with families' explanatory content conversations during their visit as the dependent variable. Predictor variables included the previously mentioned demographic factors as well as families' before-visit content talk. Neither demographic factors nor families' before-visit content talk predicted the explanatory content conversations families had during the visit. This result suggests that content talk during the museum visit was most likely influenced by activities within the exhibition itself.

A third regression examined factors that might influence families' content talk immediately after the visit. Predictors included all of the variables mentioned previously plus families' explanatory content conversations during the visit. The analysis revealed that families' explanatory content conversations during the visit as well as children's age significantly affected the amount that families talked about manufacturing content immediately after the visit, $R^2 = 0.361$, $F(2,26) = 7.35$, $p=.003$. Here, families with older children (ages 10 to 12) engaged in more content talk immediately after the visit than younger children (ages 7 to 9).

A fourth regression looked at possible predictors of the number of content conversations parents reported having with their children in the two weeks between the museum and the home visit. As before, all of the previously mentioned predictors were examined, with the addition of the amount that families talked about content immediately after the visit. The analysis showed that child gender significantly predicted the number of content conversations families had in-between the museum and home visit, $R^2 = 0.138$, $F(1,27) = 4.30$, $p=.048$. Specifically, families with girls engaged in significantly more content conversations than families with boys.

A fifth regression investigated the factors that might influence families' content talk at home. Again, all of the previously mentioned predictors were included in the analysis with the addition of the number of content conversations families had in-between the museum and the

home visit. The regression found that both the amount that families talked about content immediately after their visit and the number of content conversations families had in-between visits significantly predicted the amount that families talked about content at home, $R^2 = 0.375$, $F(2,26) = 7.80$, $p=.002$.

The sixth and final regression looked for predictors of families' content talk during the scavenger hunt activity. All of the aforementioned predictor variables were part of the analysis, as well as the amount that families talked about content at home. Here, what families talked about at home as well as parent gender affected the amount that families talked about content during the scavenger hunt, $R^2 = 0.376$, $F(2,26) = 7.83$, $p=.002$. In particular, fathers discussed manufacturing content during the scavenger hunt more than mothers.

Thus, the model provides some initial evidence that the rehearsal of family conversations around content during the museum visit can account for changes in learning talk after the visit. In addition, the model shows that the way that families' talked together after the visit, as well as the degree to which they continued to engage in content conversations, significantly predicted how families talked about everyday objects together at home. This result suggests that, over time, as families continue to explore how to talk together within museum and everyday settings, the amount of learning conversations they engage in at home will increase.

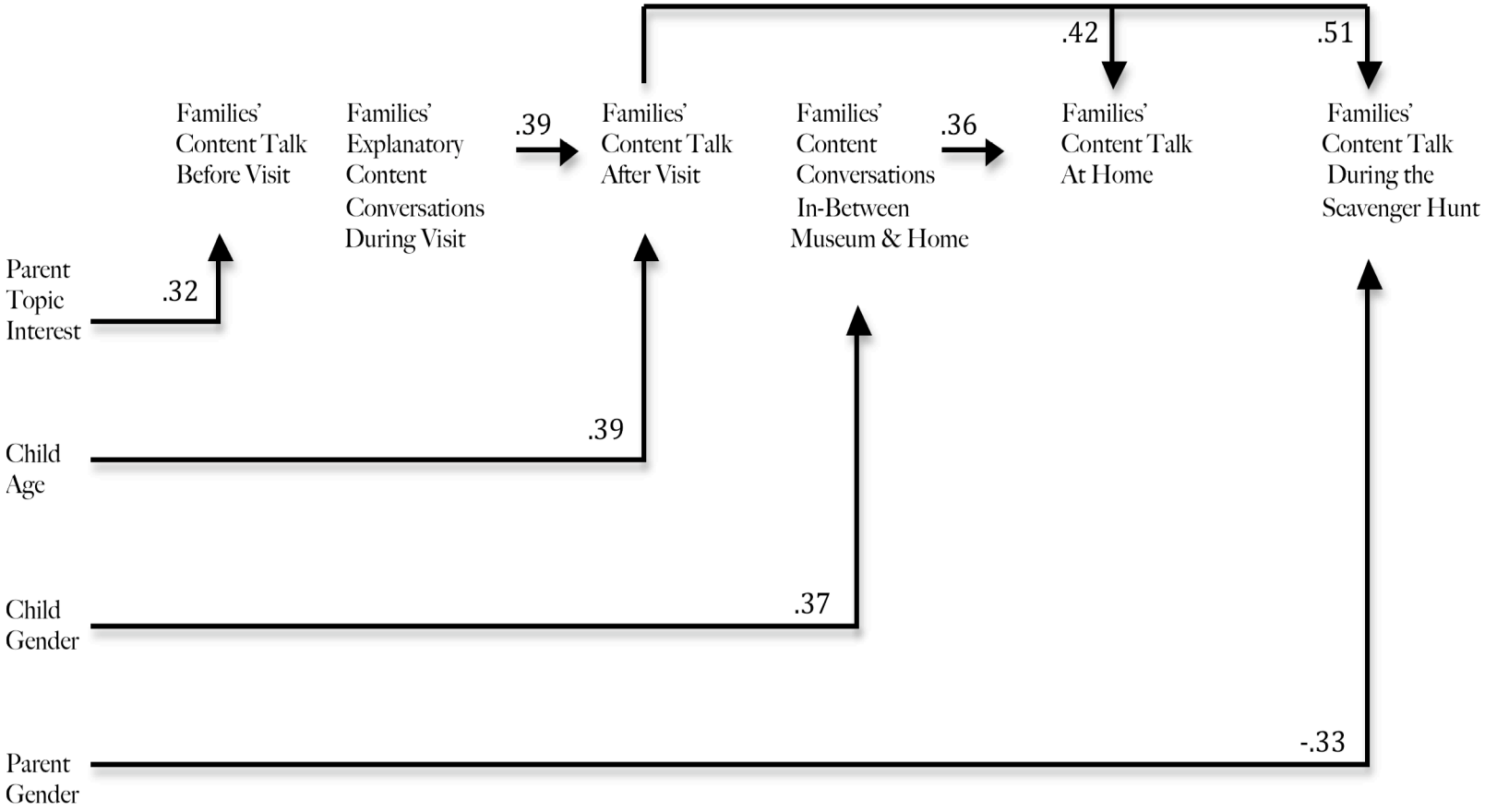

Figure 17. A Model for Changes in Family Content Talk Over Time*

* Arrows denote significant predictors

4.5 CHANGES IN CHILDREN'S LEARNING OUTCOMES

Although the main focus of this study is on changes in family learning talk, rich parent-child talk has been shown to affect learning outcomes, as demonstrated by individual knowledge gain (Borun, Cleghorn, & Chambers, 1996; Leinhardt & Knutson, 2004). We hypothesized that talk during the shared family museum experience would contribute to individual learning gains. Specifically, we predicted that children would demonstrate an increase in content understanding (here, an ability to use molding, cutting, deforming, and assembly terminology). Furthermore, we surmised that children would use significantly more process explanations to display their understanding after they had visited the exhibition with their family. In sum, we hypothesized that engaging in learning talk together in the museum would lead to positive individual learning outcomes. To test this hypothesis, we examined children's answers to an interview, conducted separately, in which the interviewee provided reasons why he or she thought that everyday objects were made in a similar way or a different way.

4.5.1 Children's Specific Content Understanding as a Learning Outcome

As before, the term, content, refers to specific manufacturing processes, and was divided by knowledge of the molding , cutting, deforming, and assembly processes. A multivariate ANOVA of children's overall content understanding revealed a significant effect for timepoint, $F(2,78) = 3.79$ $p = .027$. More specifically, pairwise comparisons indicated a significant increase

in children's overall content knowledge from before their museum visit to two weeks later at home, p=.007, d= 0.81 (see Table 4).

In terms of specific process understanding, a multivariate ANOVA showed that children's understanding of the deformation process changed significantly over time, F(2,78)= 6.94, p=.002. Pairwise comparisons indicated that children's knowledge of the deforming process significantly increased from before the visit to immediately after the visit, p=.001, d= 0.49. In addition, children's understanding of the deforming process two weeks later at home was significantly greater than their knowledge of the deforming process before their visit, p=.013, d= 0.92. A multivariate ANOVA looking at child understanding of the molding process revealed no significant differences by timepoint, F(2,78)= 1.85, p=.164. Children's understanding of the cutting process also did not significantly differ over time, F(2,78)= 1.64, p=.201. Overall, children's knowledge of the assembly process was not affected by time, F(2,78)= 2.38, p=.100. However, pairwise comparisons revealed a significant increase in children's assembly understanding from before the visit to two weeks later at home, p=.034, d= 0.58.

Table 4. Changes in Children's Specific Process Knowledge Across Three Different Timepoints[4]

	Before Visit	Immediately After Visit	Two Weeks Later At Home
Molding Knowledge	0.85 (1.43)	1.04 (1.37)	1.59 (1.60)
Cutting Knowledge	0.19 (0.48)	0.44 (0.75)	0.48 (0.70)
Deforming Knowledge	0.00 (0.00)	0.11 (0.32)	0.37 (0.57)
Assembly Knowledge	0.11 (0.32)	0.37 (0.69)	0.52 (0.94)
Total Process Knowledge	1.15 (1.90)	1.96 (2.61)	2.96 (2.51)

[4] n=27 for all child individual interview analyses

Consistent with our hypothesis, children's overall content understanding increased over time. Such findings suggest that rehearsing learning talk in a museum setting can support children's individual knowledge gains.

4.5.2 Children's Individual Process Explanations as a Learning Outcome

As before, both process and other types of explanations were examined. A series of multivariate ANOVAs were carried out looking at children's process and other types of explanations given during the individual interviews. These analyses identified a significant difference in children's overall process explanations by timepoint, $F(2,78)= .3.550$, $p=.033$. Pairwise analyses pinpointed children's process explanations at home ($M=2.15$, $SD=1.54$) as being significantly greater than their process explanations before their visit ($M=1.00$, $SD=1.59$), $p=.011$, $d= 0.73$. Other types of explanations given by children were not significant by timepoint, $F(2,78)= .080$, $p=.923$.

When demonstrating their understanding about how everyday objects were made, children used more process explanations to account for similarities and differences. Here, children seemed to be moving away from other types of explanations and towards more process-based explanations, which can be seen as an indication that children were learning about the processes used to make everyday objects.

4.5.3 Developing a Model for Children's Individual Content Understanding

This study assumes that social resources like family conversations support individual knowledge gain. Therefore, we needed to establish how changes in the amount of learning talk that families engaged in were connected to changes in children's individual knowledge. So we ran a series of

regressions, this time to produce a model that could account for changes in children's individual content understanding (See Figure 19).

We used Pearson correlations to address the relationship between families' content talk and their children's individual content understanding. A correlation matrix of all of the variables that were entered into the model can be found in Figure 18. The means and standard deviations for each of the variables in the model have appeared previously in the results section.

Five regression equations were calculated to create the model (See Appendix J). The first regression looked at factors that might predict children's individual content understanding. Demographic predictors that were analyzed included parent gender, child gender, child age, parent education level, parent manufacturing experience, parent manufacturing content interest, child manufacturing content interest, and families' familiarity with visiting museums. Families' before visit content talk was also added to the model since the joint activity occurred before children's individual interviews. Only families' content talk before the museum visit significantly predicted children's content understanding before their museum visit, R^2 =.286, $F(1,25) = 10.01$, $p=.004$.

A second regression was run with families' explanatory content conversations during their visit as the dependent variable. Predictor variables included the previously mentioned factors as well as children's content understanding before the visit. None of the factors entered into the analysis were able to explain significant variance in families' during-visit explanatory content conversations.

A third regression examined factors that might influence families' content talk immediately after the visit. Predictors included all of the variables mentioned previously plus families' explanatory content conversations during the visit. The analysis revealed that families'

explanatory content conversations during the visit as well as children's content understanding before the visit significantly affected the amount that families talked about manufacturing content immediately after the visit, $R^2 = 0.526$, $F(2,24) = 13.34$, $p<.001$.

A fourth regression looked at possible predictors of children's content understanding after the visit. All of the previously mentioned predictors were examined, with the addition of the amount that families talked about content immediately after the visit. As expected, the analysis showed that children's content understanding before the visit significantly predicted children's content understanding after the visit, $R^2 = 0.656$, $F(1,25) = 47.72$, $p<.001$.

A fifth regression investigated predictors of children's content understanding at home. Again, all of the factors we have already mentioned were entered into the equation. The analysis also included families' content talk immediately after the visit, families' content conversations in-between visits, children's content understanding after the visit, and families' content talk at home. We found that families' content talk after the museum visit as well as how families' talked about content before the museum visit explained a significant amount of variance in children's content understanding at home, $R^2 = 0.589$, $F(2,24) = 17.23$, $p<.001$.

Taken together, these results suggest that shared family talk provides a delayed payoff in terms of children's content understanding. While family content talk does not produce changes in children's individual knowledge immediately after the visit, family conversations after the museum visit, as well as the way families already talk about content before visiting the exhibition, do appear to positively influence children's content understanding at home.

	Child Content Understanding Before Visit	Child Content Understanding After Visit	Child Content Understanding At Home	Parent Gender	Child Gender	Child Age	Families' Familiarity with Museums	Parent Topic Interest	Child Topic Interest	Parent Educational Level	Parent Manufacturing Experience	Families' Before Visit Content Talk	Families' After Visit Content Talk	Families' Content Conversations In-Between Visits	Families' During Visit Explanatory Content Conversations	Families' Content Talk At Home	Families' Content Talk During the Scavenger Hunt
Child Content Understanding Before Visit	1																
Child Content Understanding After Visit	.81**	1															
Child Content Understanding At Home	.61**	.65**	1														
Parent Gender	-.18	-.28	-.15	1													
Child Gender	.10	-.02	.24	-.15	1												
Child Age	.47*	.44*	.35	.02	-.29	1											
Families' Familiarity With Museums	.27	.27	.05	.07	-.27	.31	1										
Parent Topic Interest	.30	.24	.39*	-.38*	.11	.32	.03	1									
Child Topic Interest	-.04	-.02	-.10	.32	-.39*	.16	.27	-.06	1								
Parent Education Level	.18	.05	.10	.20	-.13	.07	.22	.01	.28	1							
Parent Manufacturing Experience	.08	.17	.13	-.42*	.27	.03	-.05	.17	-.46*	-.34	1						
Families' Before Visit Content Talk	.54**	.58**	.59**	-.35	.07	.43*	.22	.56**	.02	.03	.05	1					
Families' After Visit Content Talk	.66**	.64**	.69**	-.03	-.03	.46*	-.01	.15	.08	.09	-.07	.36	1				
Families' Content Conversations In-Between Visits	.35	.22	.26	.09	.37*	-.23	.13	.18	.11	.18	.01	.25	.26	1			
Families' During Visit Explanatory Content Conversations	.20	.33	.39*	-.09	.04	.19	-.23	-.09	-.30	-.19	.22	.12	.46*	.10	1		
Families' Content Talk At Home	.19	.26	.52**	.09	.04	.06	.25	.11	.19	.21	-.01	.39*	.19	.46*	.51**	1	
Families' Content Talk During the Scavenger Hunt	.25	.29	.37	-.35	-.03	.27	.20	.24	.09	.15	-.03	.40*	.52**	.10	.06	.47**	1

* Correlations are significant at the .05 level (2-tailed); **Correlations are significant at the .01 level (2-tailed)

Figure 18. Correlation Matrix for Variables in Model of Content Understanding

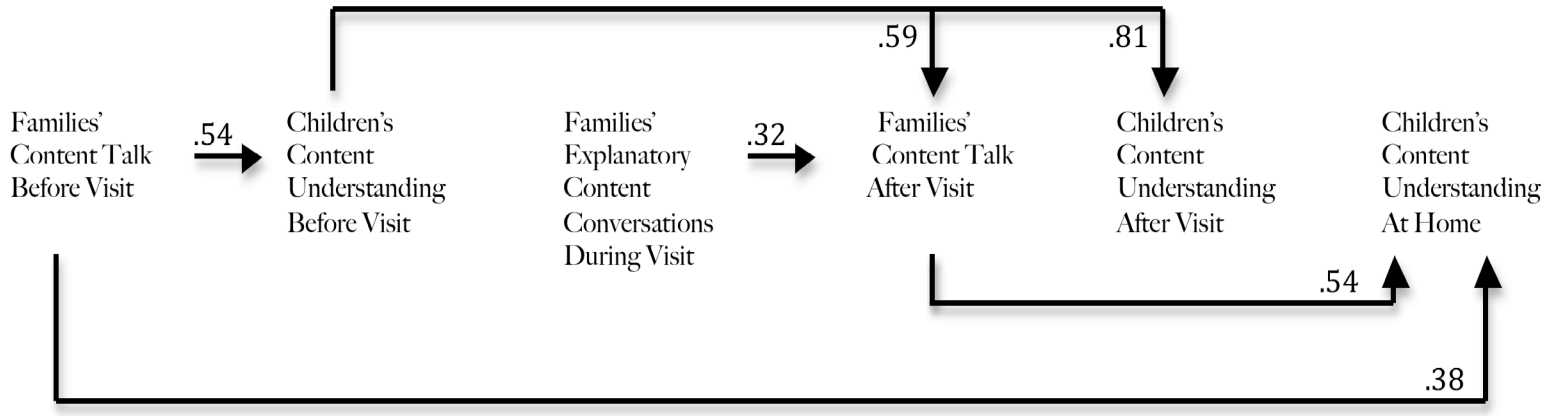

Figure 19. A Model for Changes in Children's Content Understanding Over Time*

* Arrows denote significant predictors

5.0 DISCUSSION

This study explored whether a family visit to a museum exhibition that focuses on the processes used to make everyday objects could facilitate rich learning conversations at home. In doing so, this research tested the assumption that museum experiences are valuable because they have effects, not just during, but after families leave the experience and encounter museum-related content, objects, or activities at home. We hypothesized that rehearsing ways of talking in a museum setting designed to support learning conversations would lead families to engage in more learning talk immediately after the museum visit and two weeks later at home. In particular, we anticipated that families would increase their use of content talk, process explanations, prior references and open-ended questions after their museum visit.

Two forms of evidence appear to support our hypothesis: the confirmation of positive changes in family learning talk over time, and indicators that rehearsal of conversations during shared experiences account for those changes. Looking at changes in talk over time, we found that families did increase their use of three of the four characteristics of learning conversations (i.e. content, explanations, and prior references) immediately after the museum visit. In fact, families continued to engage in more content talk and process explanations at home than they had before their shared museum experience. A series of regression analyses looking at the effect of museum conversations on subsequent content talk revealed that families' explanatory content conversations during the museum visit explained a significant amount of variance in families'

after-visit content talk. Furthermore, the amount of content conversations families had in-between the museum and the home visit predicted the amount of content talk families engaged in at home. Taken together, these findings provide initial evidence that family conversations, both in the designed museum environment and in everyday settings, facilitate families' rehearsal of learning talk over time.

Another important question that this research addresses is whether participation in a shared museum experience contributes to changes in children's content understanding. The data seem to suggest that the answer is yes, but that it takes time. Our regression model supports the idea that children rely on prior knowledge about the making of everyday objects immediately after a museum visit. However, two weeks later at home, children appear to be affected by the ways that they talked about content with their parents right after the museum visit, as well as the family's content talk before the visit. This finding implies that as families continue to rehearse learning talk outside of the museum walls, the result is an eventual increase in their children's content understanding. In other words, over time, changes in patterns of family talk look as if they yield subsequent changes in children's understanding.

Evidence from both the model of family learning conversations and children's content understanding provides some preliminary support for the idea that museums act as rehearsal spaces for families to practice talking and learning together. However, an alternative interpretation of our findings is that families were simply repeating back the learning objectives that the exhibition was designed to support, rather than practicing a broader pattern of family talk. Under this definition, families' rehearsal of talk is considered to be more of a performative act, rather than as part of the development of a shared practice. But is such a distinction problematic for learning within informal settings? Perhaps not, since classrooms are set-up to

foster similar outcomes. Here, we can think of the museum as a kind of training environment for families. Instead of rehearsing facts, families in museums are learning how to talk with one another around content.

In fact, at its most basic interpretation, the study provides some initial evidence that families' talk about museum content increases after exposure to exhibit activities, and that children's understanding of the content and their families' ways of talking about that content persists over time. But what are the mechanisms for that change? How might museum practitioners better support learning both inside and outside the museum walls? In thinking about the resources available to the learner that facilitate positive changes in conversation, we return to the Transferrable Resources Framework (see Figure 1). The framework proposes three resources that are available to the learner: environmental, social, and material. In families, as learners move from one environment to another, they encounter new resources but also take social resources such as ways of talking and interacting together with them. In addition, they can be aided by the presence of objects that carry over from one setting to the next. The current study implies that in order to change and strengthen families' social resources, museum practitioners might focus on thoughtfully designing the elements under their control: environmental and material resources.

For example, the exhibition that served as the backdrop for this study was chosen because the environment was explicitly designed to support characteristics of learning talk. The exhibition was divided into five areas to help families identify and group molding, cutting, deforming, and assembly content. Exhibit signage was written in simple, child-friendly language to help families talk together about complex manufacturing concepts. Open-ended questions on signage asked families to find similarities and differences between making something by hand

and making something by machine. The presence of these questions prompted families to link everyday ways of making with industrial processes, and elicited their use of process explanations. Videos of real factories that highlighted the series of steps used to make everyday objects also assisted families in explaining manufacturing processes to one another. Recognizable objects such as spoons, shoes, and clothes hangers were used throughout the exhibition to encourage families to make connections between previous experiences with those objects and the processes of making. In sum, family learning talk within the exhibition and after the museum visit probably occurred because the exhibit designers created an environment that was conducive for the rehearsal of such talk.

Here, the take-home point for practitioners is that exhibit designers need to keep in mind what they are designing for. Three out of the four characteristics of learning talk were at the forefront of design decisions. Signage and activities were created with the purpose of increasing content talk, process explanations, and links to prior references. Evidence from the model of change indicates that, here, the designers accomplished their goals. The fourth characteristic of learning conversations, open-ended questions, was used in service of facilitating other types of talk, rather than as a goal in and of itself. The only clear reference encouraging families to ask one another questions was embedded in the directions to an activity called the People Game. These instructions were only read by two participant families. The exhibit designers may not have created enough opportunities to support families' use of open-ended questions. Interestingly, open-ended questions were the one mode of talk that declined after the family visit. These findings suggest that if museums want to design for talk, then the talk they want to promote must be explicitly supported throughout the exhibition in both signage mediation and comprehensive exhibit activities.

A second way that practitioners can design for family learning talk is by leveraging the material resources available to the family in a way that sustains conversations around museum content over time. In other words, designers can include objects in the museum environment that are also present in the home environment to increase the likelihood that families will use these objects as conversational anchors for learning about museum topics. The exhibition in the current study was designed to include a multitude of recognizable objects with the idea that families would encounter these objects at home and strike up conversations about what they had seen and experienced within the museum. By including everyday objects in the exhibition, object-centered learning talk was promoted during the museum visit itself, and had the potential to carry over into the home environment. For example, during their visit to the How People Make Things exhibition, one mother and her nine-year old daughter, Krista, talked about the molding process while looking at the Molding Artifact Wall:

Mother: So, this is how they make all of this. They – you know how we were talking about plastic? They melt it and put it in a mold.

Krista: Oh.

Mother: Anything made of plastic.

Krista: Toothbrush.

Mother: Find the ones that have parting lines where they come – Barbies have them. You know Barbies have lines on them?

Krista: Yeah.

Mother: That's because where the molds come together.

Krista: Mom?

Mother: What?

Krista: Oh, these do. I see them.

Mother: Yeah, they have lines on them usually.

Krista: These usually do right there on the side.

- Family #37

Two weeks later, the family was participating in a scavenger hunt in their home, looking for something made by molding. Krista's mother explained that they were looking for an object that had been poured into a mold. Krista located a Barbie doll, and the family returned to the couch to describe what they had found to the researcher:

Krista: Now for molding, we got a Barbie doll.

Researcher: What makes you guys think that the Barbie Doll was made by molding?

Krista: Well, it has the lines on it and –

Mother: That was a big thing we learned at the, actually, at the museum. That when they have the lines on, it indicates where two molds come together to form something, so that's why we think the Barbie doll is.

Here, the family took what they had learned about an object they viewed in the museum, and applied it to a similar object within their homes. The family used their shared understanding of the process through which a Barbie doll is made, and connected that knowledge to the Barbie doll they had at home in a way that transformed the Barbie doll from an object of play to an object of making. When museums position everyday objects in new contexts, they seem to provide families with opportunities to use those objects as material learning resources at home. Signage mediation and contextual cues from the museum environment can potentially help

families rehearse new ways to talk around such transferrable objects. In this way, everyday objects have the potential to increase family learning conversations over time.

Our findings also have several important implications for those who study family conversation, in general. Firstly, our work suggests that family learning conversations are primarily influenced by the rehearsal of talk during shared experiences, an effect that is sustained over time. Such work adds to a growing body of research examining how family learning occurs across time and place (Barron, 2007; Bell et al., 2006; Ellenbogen, 2003; Reeve & Bell, 2009; Tzou & Bell, 2008). The data collection and analysis methods used in the current study provide family conversation researchers with additional tools to track and explain changes in talk over time through the lens of resource allocation within a learning environment. Here, the focus is on how everyday conversations and practices in the home can be repositioned as learning activities, and on identifying social resources within the family that contribute to these shifts in understanding. For instance, our study identified parent topic interest as being an important factor in what families talked about before the museum visit. This finding makes sense when we consider that families did not yet have the environmental and material resources from the exhibition available for their use, so they had to rely on their social resources. If we hold that family talk before the museum visit is similar to talk they might have at home, then it seems that a parent's interest in a topic, may guide learning conversations in the home in the absence of other resources.

Our study also hints at potential interactions between social and environmental resources that may affect family conversations in ways that warrant further study. For example, we found that content conversations taking place in everyday settings after the museum visit were influenced by child gender. Specifically, parents were four times more likely to talk to their

daughters about how everyday objects were made than they were their sons. This finding is significant for those who study family conversations at home because those who study family conversations in museums have found the opposite to be true: parents explain content more to boys than girls (Tennenbaum et al., 2001). This initial evidence intimates that although families may engage in less explanatory talk with their girls in museums, subsequent home conversations may actually be the place where girls have more opportunities to rehearse explanatory talk with their parents. In other words, social resources like gender may play a role in influencing what conditions (i.e. locations, material resources) best support family learning conversations.

A third point of note for family researchers is the relationship between family learning talk and individual knowledge. Assessments of children's individual understanding showed that children exhibited greater manufacturing content knowledge and ability to provide process explanations at home than they had before the visit. Some might be tempted to attribute this result solely to the children's comfort level at home being greater than that of the foreign museum environment. However, given the evidence, it seems much more likely that repeated rehearsal of content and explanatory talk as a family contributed to children's knowledge gains.

Additionally, we recognize that the current study appropriates terms such as rehearsal, transfer, and distributed cognition from sociocultural frameworks. In doing so, our work brings together several different research traditions. While there is still a great deal of work to be done in bridging these varied approaches, we hope to continue contributing to the field by operating at an intersection of the learning sciences. To this end, the National Research Council (2009) stated that it is crucial for the learning sciences to identify why informal educational experiences matter. The report held that there is a lack of evidence of the long-term impact of such

experiences. The current study is one of the first pieces of quantifiable evidence that museum learning experiences have effects after the family has left the museum and returned home.

In conclusion, shared family museum experiences appear to support rich learning conversations that help parents and children jointly construct an understanding of the world around them. By rehearsing ways to talk about content and objects in the world during collaborative interactions in scaffolded museum settings, families seem better prepared to discuss that content in their homes. This study presents one salient example of how museums can design effective rehearsal spaces, and provides insight into how informal settings can magnify their educational impact by utilizing material resources available in the home.

5.1 DIRECTIONS FOR FUTURE RESEARCH

This study suggests that rehearsing conversations in a supportive museum environment can increase the amount of learning conversations families have at home. Although our results indicate that changes in learning talk and children's individual understanding did occur, it is important to acknowledge that changes in families' learning talk could have been the result of the demand characteristics of the study (Orne, 1962). In other words, the presence of the researcher during data collection, as well as the prompts given to families within the study protocols, could have affected how families responded to each of the tasks. While this is a limitation of the study design regarding our pre-post data, our correlational analyses are not affected by this constraint. Furthermore, the demand characteristics of our pre-post methodology appear to impact participants less than other longitudinal studies across time and place (Ellenbogen, 2003; Tzou & Bell, 2008). In these more ethnography-based cases, the researcher

often becomes an additional social resource for the family, and sometimes even provides the family with material resources they may not have access to elsewhere. Although the ethnographic methodology provides researchers with unique access to families in a multitude of settings, it is difficult to map changes over time in a systematic way. Therefore, future longitudinal studies might implement our model of change as part of an evaluative toolkit that measures changes in family talk over time.

Additionally, we did not collect a control group due to logistical constraints, therefore, we cannot rule out the possibility that our findings reflect a test-retest effect on the assessment, rather than resulting from the impact of the exhibition experience. To address this issue, we were able to collect data from a group of families (n=8) who were demographically similar to our twenty-nine participant families in every way, except that they had visited the exhibition before. Interestingly, an analysis showed that the eight families who had already been to the *How People Make Things* exhibition talked significantly more about manufacturing content during the before-visit joint activity than families who had never visited the exhibition (See Appendix H for further comparative analyses). This result suggests that a prior visit to the exhibition had a positive impact on family learning talk. An important next step would be to determine what aspects of the exhibition contributed to changes in family learning talk. Such an examination would require an analysis of the activity structures within the space, and comparisons of the current exhibition to other settings with different content, affordances, etc. to explore whether our findings hold up across multiple types of informal experiences. Here, future work might also explore whether everyday objects support conversations in other domains besides the processes of making.

It should also be noted that the majority of participants were middle-class, college-educated families, who tend to visit museums more frequently than their working class

counterparts (Falk & Dierking, 1992). Yet some ethnographic studies imply that working class children may feel more comfortable engaging in learning talk within settings where familiar topics and activities are present (Hicks, 2001). Here, exposure to an exhibition about the processes of manufacturing could potentially activate working class parents and their children to participate in rich learning conversations together. Therefore, future studies might incorporate the basic theoretical and methodological frame of the current study, but collect more data with a greater diversity of participants. Such an expansion would provide greater depth to our understanding of the generalizability of the work.

APPENDIX A

IRB LETTER OF APPROVAL

University of Pittsburgh *Institutional Review Board*

3500 Fifth Avenue
Pittsburgh, PA 15213
(412) 383-1480
(412) 383-1508 (fax)

http://www.irb.pitt.edu

Memorandum

To: Camellia Sanford PHD
From: Sue Beers PHD, Vice Chair
Date: 6/2/2009
IRB#: REN09050136 / PRO07080058
Subject: How People Make Things

Your renewal for the above referenced research study has received expedited review and approval from the Institutional Review Board under:

45 CFR 46.110.(7)

Please note the following information:

Approval Date: 6/2/2009
Expiration Date: 6/26/2010
Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. The IRB Reference Manual (Chapter 3, Section 3.3) describes the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least **one month** prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

Please be advised that your research study may be audited periodically by the University of Pittsburgh Research Conduct and Compliance Office.

APPENDIX B

PRIOR EXPERIENCE WITH AND INTEREST IN MANUFACTURING SURVEY

Demographic Survey

1.) Have you ever made something?

a.) What have you made?

b.) What kind of activities do you do that involve making things?

c.) What kinds of tools or machines have you worked with?

2.) Do any of your child's interests involve tools, building, or making things?

a.) What activities do they do that involve making things?

b.) What have they made?

3.) Do you and your child ever make things together?

a.) What have you made? How did you make it?

4.) Do you or your child watch any television shows that describe how everyday objects are made?

a.) Which shows do you watch? What kinds of things have you seen being made?

5.) Are you interested in finding out how things are made?

a.) On a scale of 1-10 (1 being not very interested, 5 being moderately and 10 being extremely interested), how interested are you in the topic of manufacturing?

b.) How interested would you say your child is in the topic?

b.) What interests you about the topic?

5.) Do you have any factory or manufacturing experience? If yes: Doing what?

6.) Does anyone in your family have experience with manufacturing? If yes: Doing what?

7.) Have you or your child ever gone on a factory tour?

8.) Have you or your child ever checked out books on the topic of how things are made?

9.) How often do you or your child visit museums together?

0 times a year, 1-2 times a year, 3-5 times a year, more than 5 times a year

APPENDIX C

JOINT ACTIVITY PROTOCOL

Joint Activity Protocol: Version A

I'm going to show you both an object. Pretend that your mom/dad just found this object in your house. I'd like you to look at the object and talk together about how you think this object was made. When you have finished talking about the object, let me know, and I'll show you the next object.

Object 1: Greeting card *[Researcher hands greeting card to parent]*

This is a greeting card. I'd like you both to talk together about how you think this object was made.

Object 2: Ketchup bottle *[Researcher hands ketchup bottle to parent]*

This is a ketchup bottle. I'd like you both to talk together about how you think this object was made.

Object 3: Pie plate *[Researcher hands pie plate bottle to parent]*

This is a pie plate. I'd like you both to talk together about how you think this object was made.

Object 4: Picture Frame *[Researcher hands picture frame to parent]*

This is a picture frame. I'd like you both to talk together about how you think this object was made.

[Researcher hands binder of object pictures to parent]

5.) This is a coin tray and this is a fire helmet. Do you think these objects were made in a similar way or a different way? What makes you think so?

6.) This is a salt shaker and this is a flower pot. Do you think these objects were made in a similar way or a different way? What makes you think so?

7.) This is a guitar pick and this is a ring. Do you think these objects were made in a similar way or a different way? What makes you think so?

8.) This is a bar of soap and this is an soldier. Do you think these objects were made in a similar way or a different way? What makes you think so?

Table 5. Objects Used in Three Versions of Joint Activity

	Version A	**Version B**	**Version C**
Question 1	Greeting Card	Bannister	Belt
Question 2	Ketchup Bottle	Horseshoe	Chocolate Bunny
Question 3	Pie Plate	Egg Carton	Wall Decoration
Question 4	Picture Frame	Eyeglasses	Umbrella
Question 5	Coin Tray & Fire Helmet	Ice Cube Tray & Packaging	Plant Container
Question 6	Salt Shaker & Flower Pot	Pen & Knife	Coffee Cup Lid
Question 7	Guitar Pick & Ring	Ruler & Head of a Golf Club	Lock & Paper Clip
Question 8	Bar of Soap & Toy Soldier	Slide & Bath Toy	Marbles & Piggy Bank

APPENDIX D

INDIVIDUAL INTERVIEW PROTOCOL

Individual Interview Protocol: Version A

I'd like to talk to your son/daughter about some objects. Please find a quiet place to answer the same questions on this sheet of paper. I'm interested in what you both think about these objects on your own. We'll let you know when we are done.

Now, I'm going to show you a set of objects and ask you some questions about them.

[Researcher hands binder of object pictures to child]

1.) This is a stapler and this is a screwdriver. Do you think these objects were made in a similar way or a different way? What makes you think so?

2.) This is a soda can and these are milk bottles. Do you think these objects were made in a similar way or a different way? What makes you think so?

3.) These are gloves and this is a plane. Do you think these objects were made in a similar way or a different way? What makes you think so?

4.) This is a road sign and this is a trumpet. Do you think these objects were made in a similar way or a different way? What makes you think so?

Table 6. Objects Used in Three Versions of Individual Interview

	Version A	**Version B**	**Version C**
Question 1	Stapler & Screwdriver	Ice Cream Scoop & Scissors	Lipstick Tube & Fire Extinguisher
Question 2	Soda Can & Milk Bottles	Pot & Measuring Cup	Food Tray & Fishbowl
Question 3	Gloves & Plane	Toothpicks & Keys	Wallet & Toy Train Tracks
Question 4	Road Sign & Trumpet	Gears & Garbage Can	Necklace & Badge

APPENDIX E

PARENT PROMPT FOR JOURNAL ENTRIES

After their museum visit, parents received a packet with ten blank journal pages similar to the home diaries used by Callanan and Oakes (1992). Each page was used to record one conversational episode. Parents were asked to fill out a page whenever they have a conversation with their child regarding how everyday objects are made. The duration of these self-reports was approximately two weeks.

Like Callanan and Oake's diaries, the journal text asked parents for the following information:

- The date and time that the object conversation took place
- The situation in which the conversation occurred
- Who took part in the conversation
- A summary of the conversation itself

Parents were given the following general prompt to help them organize their observations:

Please write down any interesting conversations that you have with your child around the making of everyday objects over the next two weeks. Provide as many details as you can remember. Be sure to include the following in your descriptions:

- Where were you when the conversation took place?
- What were you and your child doing?
- Did anyone besides you and your child participate in the conversation?
- What did you talk about? (i.e. what was the topic?)

The following example journal entry was also included as part of the packet:

Date: _____April 5, 2009_____ Time: _____Around 6PM_____

Please summarize the conversation you had with your child:

We were talking about what Jen did at school today. She said she learned about Egypt and she made a mask. The teacher wet plaster strips and put them over Jen's face. I asked her to describe what it felt like. She said it was slimy at first, but then got very dry. I told her there was still some on her jaw, so she got up and washed it off. When she came back, she told me more about Egypt.

Where did this conversation take place?

During dinner, at the table.

What were you and your child doing?

Eating dinner.

Who else participated in this conversation?

No one. Her father was still at work.

APPENDIX F

SCAVENGER HUNT PROTOCOL

Scavenger Hunt Protocol

Now, we are going to play a game. I am going to show you both an object, and I'd like you to work together to find an object in your home that was made in a similar way, but is not the same object. For example, if I show you a shoe, you don't need to look for another shoe. Feel free to talk to each other while you look for the object. When you have found an object that was made in a similar way, I will move to the next object. I am going to show you a total of four objects. After you have collected four objects, we are going to come back here and talk a little bit about the objects you chose. I am going to come with you so that I can record the scavenger hunt on this video camera. Any questions? Okay, let's get started.

Object #1: This is a container for cereal. I want you to work together to find an object in your house that was made in a similar way.

Object #2: This is a checker. I want you to work together to find an object in your house that was made in a similar way.

Object #3: This is a lightbulb. I want you to work together to find an object in your house that was made in a similar way.

Object #4: This is a cookie cutter. I want you to work together to find an object in your house that was made in a similar way.

Follow-up question for each object chosen: You thought that the [chosen object] was made in a similar way as the cereal container. Why do you two think so?

Now, I want you to work together to find four more objects in your home.

Object #5: Something that was made by cutting.

Object#6: Something that was made by assembly.

Object #7: Something that was made by molding.

Object # 8: Something that was made by deforming.

If you don't know what those words mean, use your best guess. Make sure to talk to each other during the scavenger hunt. When you have found the four objects, come back here and we'll talk about the things you chose.

Follow-up question asked for each object chosen: You think that [chosen object] was molded. Why do you two think so?

APPENDIX G

EXAMPLES OF FAMILIES' TALK DURING THE MUSEUM VISIT

The following examples represent family learning conversations that took place in each of the five areas of the *How People Make Things* exhibition: the Entry, Molding, Cutting, Deforming, and Assembly areas. These examples indicate that *How People Make Things* was indeed a place where families had productive discussions about how everyday objects are made.

Example #1: Entry Area

A mother and her seven year-old daughter, Kellan, arrive at the entrance of the How People Make Things exhibition. They approach the Baseball Bat Display, an exhibit that shows five different pieces of wood in various stages from raw material to finished product. Kellan's mother begins the conversation by asking her daughter to identify the object in front of them.

MOTHER: What are we making here?

KELLAN: A bat.

MOTHER: A bat.

KELLAN: Wood that round it with that.

MOTHER: Now you know – what kind of machine makes this? Daddy has one down in his wood shop. What is that called? Do you remember?

KELLAN: A wood-twisting thing.

MOTHER: It does twist. Do you remember what it's called?

KELLAN: No.

MOTHER: It starts with an L. La-

[Kellan's mother redirects her daughter's attention to the signage above the display]

MOTHER: No, up here. Read it. A wood cutting machine called-

KELLAN: Laths.

MOTHER: Lathe. It's called a lathe and do you remember what it does?

KELLAN: No. It shaves it.

MOTHER: Well, you said it. What does it do?

KELLAN: Um, spins.

MOTHER: It spins the wood and then they have those chisels like those special knives that they run down. And they're showing you that this is a what? Is that a bat?

KELLAN: No.

MOTHER: What is it?

KELLAN: Part of a bat.

MOTHER: No. Look at it.

KELLAN: Um –

MOTHER: A table leg.

KELLAN: Oh yeah.

MOTHER: But look how similar it is to a bat.

KELLAN: What's this?

MOTHER: That's just – it starts as a block. It just shows you the progression of what you can do but you – actually this is getting to be the bat. Okay, but look how much it looks like a table leg. So Mommy was wrong.

- Participant #46

In the excerpt above, Kellan is the first to mention the process through which the bat was made, but she uses common vernacular to describe that process (i.e. "wood that round it with that"). Kellan's mother evokes a prior shared experience with machines in her husband's shop in order to help her daughter name the tool used to create the baseball bat. Kellan uses her memories of the machine and the signage accompanying the exhibit to identify the machine and recalls that it twists, shaves, and spins. Kellan's mother is able to synthesize her daughter's

comments into an explanation of how the lathe cuts wood. Although Kellan's mother misidentifies the object being made at first, she uses the display as a resource to show her daughter that objects can be made using a series of steps.

Example #2: Cutting Area

A mother and her 9 year-old son, Wesley, walk up to a machine called the 3-Axis Mill. This activity shows visitors how machines can cut three-dimensional objects like wax blocks. The pair begins their interaction by taking turns reading the instructions provided in order to figure out what the machine is and what it does.

WESLEY: This is – Wow, this.

MOTHER: Here. Want me to hold that? Look. Here's your – your instructions are up here?

WESLEY: What to do? *Turn green handle to move the wax –*

MOTHER: *Left to right.*

WESLEY: *This is –*

MOTHER: *This is the x-axis.* Then you *turn the orange to move the wax back and fourth. That's your y-axis.* Then you *turn the blue to move up and down*. And then you *press the black button to blow the shavings away.* Here why don't you blow the shavings away and you can start over. Will it blow them away or no? No.

WESLEY: Well that's how it's supposed to be.

MOTHER: Okay. Go for it.

WESLEY: What am I supposed to do?

MOTHER: It cuts like a drill. *3-axis mill cuts like a drill but in three different directions to create a three-dimensional shape.* So you can go up and down, backwards, and diagonally to make a hole in the wax. No, that's it. You're good. It's going. So if you want to go up and down.

WESLEY: How is it making it?

MOTHER: All right. Up and down is the blue. You're just going – so first you want to go up and down. First you want to get it into the wax. There you go. First go into the wax. Now you're drilling. Okay. Now do you want to go diagonally or side to side? Oh, there you go. And now you're going sideways. Does it go any deeper into it? Can you get it to go deeper?

WESLEY: Yeah.

MOTHER: There you go. You can carve Wesley into it.

WESLEY: So, this is forward.

MOTHER: That's diagonal. See, look. Well, back and fourth. Sorry it's back and fourth. Green is left to right.

WESLEY: Going deeper.

MOTHER: And blue is up and down.

WESLEY: So this goes forward.

MOTHER: Yep.

WESLEY: Backwards.

MOTHER: Yep. So what are you going to do?

WESLEY: Diagonal.

MOTHER: Are making a W? [laughs] That's a deep one over there. It's hard to - somebody took a chunk out. I don't – will it go down that far? No.

WESLEY: I can't do it.

MOTHER: Okay. Well, that was a good try. Let's go over here.

- Participant #8

In the example above, the family's talk around the activity is heavily supported by directional signage. After his mother reads the signage, Wesley is still unclear about what to do. So his mother references a machine that her son might have more familiarity with, a drill. She

also rephrases the instructions in more colloquial terms, letting her son know that the purpose of the activity is to "make a hole in the wax". Wesley continues the conversation by questioning how the machine is used to make objects. His mother explains that in order to drill something, the machine needs to move deeper into the wax. Once her son accomplishes this first step, Wesley's mother challenges him to carve his name into the wax. Wesley now understands how the machine works and demonstrates his knowledge by showing his mother what each crank on the machine does. Since the block of wax is limited in size and has been used by other visitors, Wesley is unable to carve his name, so his mother walks him over to another activity where Wesley can hand carve a block of wax.

Example #3: Molding Area

A father and his twin seven year-old girls, Katie and Aster, watch a machine called the Injection Molder. This activity demonstrates how a real industrial machine molds a spoon. Katie and Aster's father is initially drawn to the activity by its title, and soon calls his girls over to the machine.

FATHER: *Injection mold a spoon*. Oh, wow. All right.

[Katie & Aster are over at the Pellet Wall, an activity where screens covering pellets used in the injection molding process can be touched]

KATIE: Aster, feel what it feels like.

FATHER: All right. Watch this girls. Come here.

[Katie and Aster join their father at the Injection Molder]

FATHER: *Plastic pellets go from the hopper to the heater core to be melted. The melted plastic is injected with a burst of air into the mold.*

KATIE: Cool.

FATHER: Watch this. We're going to make a spoon. *The plastic is cooled inside the mold and takes the shape of a spoon.*

ASTER: What?

FATHER: The mold opens and – watch.

KATIE: Where does it make the spoon at? Where can you see it?

ASTER: Under here?

FATHER: Yeah. It in- it takes a minute to a make it. So you see these – see these little plastic pellets here girls.

KATIE: *[counting]*

FATHER: See those plastic pellets in that bucket?

ASTER: Yeah.

FATHER: That's what makes the spoon.

ASTER: I didn't know that.

FATHER: It melts it with heat into a mold.

ASTER: *[counting]*

FATHER: No, don't count like that.

ASTER: *[counting]*

KATIE: *When picking up your spoon from the bin, pick it up by the handle, not the –* you don't get to keep them. You just get to look at them.

FATHER: No, you get to –

KATIE: You just get to look at them.

FATHER: Oh, ours spit out over there. See it came out – oh, let's do it again. I missed it coming out. Let's watch over here. Yeah, do it again. Cause it comes out – I want to watch it come out.

KATIE: Hey, you can actually reach the spoon.

FATHER: Yeah.

KATIE: Tons of people's went out that way.

FATHER: All right. Watch this.

KATIE: What?

ASTER: I want to see it just go down.

FATHER: *The piece attached to the spoon handle is where the plastic was injected into the mold. This piece is called a sprue. When cooled the sprue can be twisted off.* That's the extra piece of plastic on there.

KATIE: Huh?

FATHER: You'll see when it comes out. Here it is.

ASTER: They shooted it out the wrong way again.

FATHER: That's okay. But here let me show you. Come here, Aster. See that extra piece there? That's called the sprue. That can be twisted off.

KATIE: Don't twist it off, Dad.

FATHER: Keep it for a minute. Okay.

- Participant #17

Katie and Aster's father's ability to explain the injection molding process is facilitated by signage. He identifies the object being made (a spoon) for his daughters, and also points out the tool used to make that object (i.e. a mold). The girl's father then tries to focus his girls' attention on the opening of the mold, but Katie and Aster are preoccupied with determining the location that the spoon can found. The father reassures the girls that making things takes time, and decides to take a different approach. He changes the topic to pellets, and links that material to the object being made. He then uses the discussion of pellets to describe the molding process to his daughters.

The family decides to make another spoon because they all missed the spoon being ejected from the mold. Katie and Aster's father uses signage to change the focus of the conversation again, this time to a by-product of the molding process called the sprue. Now knowing what the excess material is for, Katie decides to keep the sprue on the finished product.

Example #4: Deforming Area

A mother and her sons, eight year-old Carson and nine year-old Peter, walk up to the Rolling Mills and Toggle Press, a set of three machines in which visitors place a penny into a slot, and turn a wheel or pull a lever to change the shape of their penny. The mother encourages her sons to read the signage before beginning the activity.

MOTHER: Read, read that. Read that.

CARSON: *Put your penny in the coin slot. Turn the crank to –*

MOTHER: *Deform your penny*. So it's making your penny misshapen. Where is your penny?

PETER: Mine?

MOTHER: No his.

CARSON: It's supposed to fall into there.

MOTHER: Here, put one more in. Now turn it just in one direction. Turn it that way. Did it go down? Keep turning it around and around and around. You have to put some muscle into it. There. That's what's going to make it happen.

PETER: Here. I'll try when he's done.

MOTHER: There you go. There it is. You have to keep pushing it the same direction.

CARSON: It's like a Japanese coin.

MOTHER: Japanese? Why Japanese?

CARSON: Cause Japanese coins are usually like oval shape.

MOTHER: How do you know?

CARSON: Cause I've seen one.

MOTHER: Oh.

CARSON: *Place your deformed penny from rolling mill one into the coin slot. Turn the crank to flatten and texture.*

MOTHER: Cool.

CARSON: Now I smash it.

MOTHER: Wait. Read this. Oh, okay. We're good.

CARSON: No I like it like this.

MOTHER: Oh you don't – here I'll give you another one you can do the other one with that. Okay.

CARSON: Can I just do another one like this?

MOTHER: I want you to do – here you can have this one but do one in there because I want to see what it looks like at the end. No, no, no, no. After you put it through those two things. You have to do that first.

PETER: Mom. Mom, come here. You can see the number.

MOTHER: Wait a minute. You put it in there and then turn it and it falls out here. And then you're supposed to put it in this thing.

MOTHER: You slide that in. Lift up. Lift up. Ow, ow, ow! You stepped on my toe. It already came out, bud.

CARSON: Oh, it did.

PETER: Cool. Mom, look. Feel it. It's all wavy.

MOTHER: Uh huh. Do you want to do another one?

CARSON: Yeah.

MOTHER: I've got plenty of – oh. That's Peter's. Here I have plenty of pennies.

PETER: Yes. Cool.

MOTHER: I wonder if a nickel would work.

PETER: No.

MOTHER: Is that mine?

PETER: Yeah. One of them is yours.

MOTHER: Here, we should take one home to Dad each – on each step of the way.

PETER: Yeah, so you get one, and then I'll just do this one.

MOTHER: Poor Lincoln.

PETER: Keep that one for Dad.

MOTHER: Poor Lincoln.

PETER: {laughs}

[The family makes three more pennies, while talking together about getting the machine to work properly.]

CARSON: How am I supposed to stick it in?

MOTHER: I think you only have to do it once. Let me see yours. Neat. I wonder what would happen if you went to Giant and gave this to a lady like when you're paying for something.

CARSON: Hey, can I have a dime?

MOTHER: No.

CARSON: I want another penny.

MOTHER: I don't think it would work. I kept a smooth one. Do you want a smooth one? Well, you can keep that. Do you want to go to a different thing?

CARSON: Hold on.

MOTHER: Just put those in your pocket.

- Participant #16

In the example above, the mother initiates the conversation and the activity by defining the deformation process. She also paraphrases the signage, telling her sons that "muscle" is "what's going to make it happen". While talking about content, Carson & Peter's mother also tries to help them complete the activity successfully by letting her sons know that the crank has to be turned in the same direction in order to work. After making a flattened coin, Carson references his prior knowledge about foreign money, likening the shape of the penny to the shape of a Japanese coin. Next, Carson uses the signage vocabulary and his own vernacular (i.e. "smash it") to explain what he is doing to the coin.

At this point, Carson decides that he wants to keep his penny in an unfinished state. His mother provides the boys with more material resources (i.e. pennies), and encourages them to go through all of the steps. The family decides to make pennies that have gone through each step of the process and bring them home to show their father. At the end of the interaction, Carson and Peter's mother wonders if the pennies can be used in other locations, like the grocery store.

Example #5: Assembly Area

A father and his nine-year old son, Scott, walk up to the Golf Cart Assembly. In this activity, visitors can take body panels, gauges, steering wheels, and tires on and off of the frame of the vehicle. Scott starts the interaction thinking that the activity is about the function of the car, but his father quickly clarifies that the purpose of the golf cart is to demonstrate the assembly process.

SCOTT: Oh, I don't know how to drive yet. I want to learn how to.

FATHER: This isn't about driving. It's about putting together, assembly. What parts do you think these would make?

[Scott removes the steering wheel]

SCOTT: Whoa!

FATHER: That's called disassembly.

SCOTT: What?

FATHER: No.

SCOTT: I didn't mean to.

FATHER: I know.

SCOTT: Oh.

FATHER: Here take a look. I want to show you something. Watch, come here. See that. This is a body panel. Do you see it?

SCOTT: Uh huh.

FATHER: Take it and you put it on here.

SCOTT: I know how to do it.

FATHER: Well that's – that's not how you do it. What you're supposed to do is you're supposed to build the car.

SCOTT: Where?

FATHER: Do you want to – do you want to do some assembly stuff?

SCOTT: I know, but how do you drive this thing? How do you make it go ahh?

FATHER: You don't because it doesn't. That's not what it's here for. It's here to be built. Take a look back here. Here. Take a look here. This would be an engine cover compartment.

- Participant #11

During the entire interaction above, Scott thinks that the golf cart is there to be driven, while his father understands that the activity is about the process of assembly. Scott's father

makes a number of conversational and attention-focusing moves during the exchange, using the exhibition as an opportunity to provide a process explanation to his son. For instance, when Scott accidently pulls the steering wheel off of the vehicle, his father uses it as an opening to introduce another term, disassembly. Scott's father then tries to get his son to physically understand the process of assembly by encouraging Scott to place a body panel on the frame of the vehicle. However, Scott still thinks that the purpose of the vehicle is to be driven, so his father once again lets Scott know that the goal of the activity is to assemble the golf cart.

The examples above demonstrate that rich learning talk did occur during the museum visit. Consistent with the model of change, rehearsal of rich learning talk in the museum made an impact on families' subsequent conversations around everyday objects.

APPENDIX H

COMPARISON OF FAMILIES WHO HAD VISITED THE EXHIBITION BEFORE TO FAMILIES WHO WERE VISITING THE EXHIBITION FOR THE FIRST TIME

Due to the nature of the study, it is possible that families' positive gains in learning talk simply reflect the fact that parents and children became more familiar with the joint-activity task. In order to address this issue, we looked at the before-visit measures of our twenty-nine participant families and compared them to data we collected from eight families, who had been to the How People Make Things exhibition before. If the data from the two groups was similar before entering the exhibition, then it was more likely that the nature of the questions asked, rather than the museum experience, could account for the changes we observed. But if families who had been to the exhibition before talked significantly more about how everyday objects are made than families who had never been to the exhibition, then we could be reasonably assured that the exhibition, rather than repeated questioning, was a better explanation for changes in family talk.

When we compared children's contributions to family learning talk before the museum visit, we found that children who had been to the exhibition before engaged in significantly more content talk overall than children who had never visited the museum exhibition, $F(1,36) = 27.38$, $p<.001$ (See Table 6). Specifically, children who had been to the exhibition before mentioned the molding process significantly more than children who were unfamiliar with the exhibition, $F(1,36) = 24.81$, $p<.001$. Children familiar with the exhibition also spoke about the cutting process more than children who had never been to the exhibition before, $F(1,36) = 4.43$, $p=.042$. In addition, children who had previously visited the exhibition talked more about the deformation process than children who were unfamiliar with the exhibition, $F(1,36) = 4.22$, $p=.047$. Children who were familiar with the exhibition also discussed the assembly process more than children who were unfamiliar with the exhibition, $F(1,36) = 8.65$, $p=.006$. Children who were familiar with the exhibition also gave more process explanations regarding how

everyday objects are made than their unfamiliar counterparts, $F(1,36) = 6.75$, $p=.014$. In sum, children who had visited the How People Make Things Exhibition before engaged in significantly greater amounts of learning talk than children who had never been to the exhibition.

Table 7. Comparison of Children Familiar and Unfamiliar with the Exhibition

	Children Who Had Been to the Exhibition Before (n=8)	**Children Who Were Visiting the Exhibition for the First Time (n=29)**
Molding Talk	6.13 (3.87)	1.31 (1.89)
Cutting Talk	2.50 (1.60)	1.21 (1.52)
Deforming Talk	0.88 (1.13)	0.28 (0.59)
Assembly Talk	2.63 (2.62)	0.83 (1.10)
Total Process Talk	12.13 (5.62)	3.62 (3.58)
Prior Experience Mentions	0.88 (1.36)	0.66 (0.86)
Process Explanations Given	8.13 (3.36)	4.66 (3.34)
Other Explanations Given	3.12 (3.18)	3.90 (3.26)
Open-Ended Questions Asked	0.75 (1.75)	0.10 (0.31)
Closed-Ended Questions Asked	1.38 (2.72)	0.59 (0.73)

We also compared learning talk between parents who were familiar and parents who were unfamiliar with the exhibition (See Table 7). We found that parents who were familiar with the exhibition engaged in more content talk overall than parents who had never been to the exhibition, $F(1,36) = 14.62$, $p=.001$. An ANOVA indicated that parents who had been to the exhibition before made more mentions of the molding process than parents who had never visited the exhibition, $F(1,36) = 6.12$, $p=.018$. Parents who had visited the exhibition before also engaged in more talk around the process of deformation than parents who had never visited the exhibition before, $F(1,36) = 9.14$, $p=.005$.

Table 8. Comparison of Parents Familiar and Unfamiliar with the Exhibition

	Parents Who Had Been to the Exhibition Before	**Parents Who Were Visiting the Exhibition for the First Time**
Molding Talk	5.50 (2.39)	3.07 (2.48)
Cutting Talk	2.25 (1.04)	1.45 (1.33)
Deforming Talk	2.88 (2.90)	0.93 (1.07)
Assembly Talk	2.38 (1.41)	1.83 (1.37)
Total Process Talk	13.00 (4.34)	7.28 (3.59)
Prior Experience Mentions	2.00 (1.41)	1.79 (2.21)
Process Explanations Given	5.88 (2.10)	4.72 (2.46)
Other Explanations Given	1.75 (1.39)	2.34 (1.95)
Open-Ended Questions Asked	5.75 (3.85)	6.07 (3.65)
Closed-Ended Questions Asked	10.75 (4.20)	16.93 (10.72)

In sum, parents and children who had been to the exhibition before did engage in more learning-related talk than parents and children who had never been to the exhibition before. These group differences lead us to conclude that visiting the exhibition changed how families talked together about how everyday objects are made. Since this comparison was done during the first iteration of researcher questioning, we can be reasonably assured that the exhibition had a significant effect, and that repeated questioning most likely did not have a significant impact on the results of this study.

APPENDIX I

REGRESSION EQUATIONS FOR MODEL OF CHANGES IN FAMILY CONTENT TALK

Families' Before Visit Content Talk = 2.262 + .562 Parent Topic Interest

Families' After Visit Content Talk =

-8.744 + .39 Families' During-Visit Explanatory Content Conversations + .389 Child Age

Families' Content Talk In-Between Visits = .412+ .371 Child Gender

Families' Content Talk At Home =

10.587 +.416 Families' After Visit Content Talk +.355 Families' Content Talk In-Between Visits

Families' Content Talk During the Scavenger Hunt Activity =

22.895 + .507 Families' After Visit Content Talk - .33 Parent Gender

APPENDIX J

REGRESSION EQUATIONS FOR MODEL OF CHANGES IN CHILDREN'S CONTENT UNDERSTANDING

Children's Before Visit Content Understanding =

-.863 + .535 Families' Before Visit Content Talk

Families' After Visit Content Talk =

9.484 + .593 Children's Before Visit Content Understanding

+ .315 Families' During-Visit Explanatory Content Conversations

Children's After Visit Content Understanding =

.683 + .81 Children's Before Visit Content Understanding

Children's Content Understanding At Home =

-1.769 + .537 Families' After Visit Content Talk + .377 Families' Before Visit Content Talk

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