MUSEUM SIGNAGE AS DISTRIBUTED MEDIATION

TO ENCOURAGE FAMILY LEARNING

by

Kyungyoun Kim

B.S., Yonsei University, Seoul, Korea, 1997

M.A., Yonsei University, Seoul, Korea, 1999

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This dissertation was presented

by

Kyungyoun Kim

It was defended on

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and approved by

Ellice Forman, Professor, Department of Instruction and Learning

Christian Schunn, Associate Professor, Department of Psychology

Michael Ford, Assistant Professor, Department of Instruction and Learning

Kevin Crowley, Associate Professor, Department of Instruction and Learning

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Kyungyoun Kim, Ph. D

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Many prior studies conducted in museums have focused primarily on exhibits as the main objects for learning. Less progress has been made in studying signage as another meaning-making tool in museums. The present study was designed to understand the role of signage in family learning by answering the following research questions, “How does signage about exhibit content or interaction strategies affect parents’ and children’s learning and their engagement?” and “What is the role of parent prior knowledge on parents’ and children’s learning and their engagement?” To address these questions, 45 parent-child dyads with children aged six to seven years were recruited to engage with two exhibits about cars. Fifteen parent-child dyads were assigned to each of three conditions, created by two different types of signage: 1) Content and interaction signage condition, 2) Content signage condition, and 3) No signage condition. In each condition, eight parents with low knowledge in the car domain and seven parents with high knowledge were recruited.

Findings showed that parents and children learned and engaged differently across the three signage conditions. Both children and parents in the conditions with signage learned more than children and parents in the no signage condition. By using information from signage, parents in the two signage conditions were able to identify the content of the exhibit more quickly and to shape appropriate educational messages in their conversations with children.

Findings also showed that parents with high knowledge were more likely to have the exhibit-focused engagement, which was often oriented to their own interpretation and not always beneficial for children's learning. However, by showing that parent-child dyads in the content and interaction signage condition were most likely to operate and observe the exhibit appropriately and most likely to describe evidence and make appropriate inferences, this study suggested that the interaction signage can be a way to support parents with high knowledge. This study suggested that signage is not only a tool for communicating about the learning opportunities in the exhibit but it can be also a tool for mediating the usage of the exhibit.

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CHAPTER 1

INTRODUCTION

Family Science Learning in Museums

How we think about children as science learners has changed in a positive way, moving from a "half-empty" view to a "half-full" view. For many years, children had often been regarded as "universal novices" because of their apparent lack of learning capacity, inability to use strategies, and meta-cognitive limitations (Brown & DeLoache, 1978). However, when developmental psychologists began looking a little more closely, children actually appear to know a whole lot more than prior research might have suggested (DeLoache, Miller, & Peierroutsakes, 1998; Gelman, 1999; Siegler, 1997). For example, research has shown that young children are able to build surprising expertise and competence which allow them to engage in fairly advanced reasoning, even at relatively young ages (e.g., Chase & Simon, 1973; Chi, Hutchinson, & Robin, 1989; Chi & Koeske, 1983). Relevant to this dissertation, science, in particular, has been described as a domain in which children are well-suited to learn (Brown, Campione, Metz, & Ash, 1997; Gelman & Williams, 1998).

The field's view of children's early experiences in everyday contexts has also recently changed. In everyday contexts, children build intuitive, simple, and informal concepts by engaging in everyday activity, observing how the world works, and using their everyday language. From these experiences, children are often referred to as "little scientists" or "intuitive scientists" (Kuhn, 1989). However, in traditional educational settings, children's everyday language and intuitive ideas from their early everyday experiences have often been differentiated from those used in formal education and school. Consequently, everyday language and ideas were seen as things to be changed through formal education. However, today many cognitive psychologists and science educators have begun to see that children's early understanding of the world and ways of thinking and talking in everyday contexts are productive resources for later learning rather than obstacles which inhibit later formal learning (e.g., diSessa, 1993; Minstrell, 2001; Smith, diSessa, & Roschelle, 1993; Warren, Ballenger, Ogonowski, & Rosebery, 2001).

Based upon these views, if children could engage in a familiar activity or context while receiving appropriate social support from others, it is believed that they could develop sophisticated understandings of the world. Children develop as reasoners who identify variables, determine causes, and develop and refine theories (Brown et al., 1997). Fueled by children's own curiosity, these kinds of early experiences, in which they are provided appropriate hints and support to find patterns in the world, can help them to grow as people who understand scientific phenomena and the nature of the scientific process, and who make use of that knowledge in their lives (Simon, 2001). Therefore, rather than considering whether or not children can learn science, the focus should be on finding appropriate ways to support children's early science learning, given that children can learn science through experiences that are matched well with their unique needs, interests, and abilities (AAAS, 1999).

This study focuses on ways to support children's learning about science-related content in museums. Museums, as an informal learning context, free people from depending solely on individual cognition, pure thought, and symbol manipulation, and enable them to learn through shared cognition, tool manipulation, contextualized reasoning, and situation-specific competencies (Resnick, 1987). Today, more and more museums have provided unique learning experiences to visitors by letting them freely explore exhibitions, following their own interests and pace (Paris & Hapgood, 2002; Ramey-Gassert, Walberg, & Walberg, 1994). Museums have functioned as learning contexts that provide people with opportunities to engage in different sociocultural practices (Matusov & Rogoff, 1995).

Museums have been seen as beneficial learning contexts particularly for children. Museums adopt the way that children naturally engage in learning through hands-on activity (Paris, 2002). In museums, children learn with their family and friends by sharing what they observe, engaging in activities, and constructing meaning by connecting these novel experiences with prior knowledge or experiences (Borun, 2002). In this way, learning in museums is well-suited to children's everyday life and is supportive of individual differences in interests and talents (Schauble, Beane, Coates, Martin, & Sterling, 1996). More and more parents appreciate these hands-on learning opportunities in this out-of-school setting (Melber & Abrahan, 2001), bringing their children to museums with the goal of providing object-based unstructured learning experiences, which are often not present in the school setting (Edeiken, 1992).

Museum Learning and Signage

From the perspective of distributed cognition, tools often support people in accomplishing things that they might not do without them. In particular, studies of how tools affect the process of human cognitive activity indicate that tools function to reorganize the structure of activity and transform a task to be more easily achieved (Cole & Griffin, 1980; Hutchins, 1990, 1995). As the primary role of many museums has shifted from preservation or research to the education of the public (Ames, 1988; Bierbaum, 1988; Semper, 1990), museum professionals have paid attention to signage as a tool for helping visitors' learning in museums (Bitgood, 1996; McManus, 1986; 1989; Screven, 1992; Serrell, 1996; Schauble et al, 1996). In particular, signage has been identified as a tool for museums to communicate with visitors about the exhibit and to help visitors' meaning-making beyond what visitors can infer on their own from an object.

So far most signage studies have focused on how thoroughly visitors are likely to read the signage (e.g., MaManus, 1989; Bitgood, Nichols, Patterson, Pierce, & Conroy, 1986) or on how to design effective signage for holding visitor's attention (e.g., Arndt, Screven, Benusa, & Bishop, 1993; Cota & Bitgood, 1994; Bitgood, Pattern, & Benefiled, 1992; Hirschi & Screven, 1988). These studies have shown that well-designed signage and its proper installation on the museum floor can increase visitors' signage reading rate. However, these studies are limited in the extent to which they provide further information on how visitors make use of signage as a tool to support talk or how signage changes visitor's meaning making and learning.

Some museum researchers have begun to identify how to use signage as a tool to boost visitors' dynamic meaning making processes, which are often achieved through negotiation and interaction between visitors and tools (Rahm, 2002) in the interactive museum context (Bitgood, 1996; Knutson & Crowley, 2005; Serrell, 1996). In particular, besides providing disciplinary content relating to exhibits which helps visitors to understand potential learning opportunities, Knutson and Crowley (2005) suggested that signage needs to be designed to scaffold interactions around the exhibit so that parents can lead children through more meaningful learning conversations during their visit.

Often parents have been described as children's best learning partners in museums (Crowley & Callanan, 1998; Crowley & Galco, 2000; Gleason & Schauble, 2000; Guberman, 2003). In particular, early family learning studies in museums focused on the parent's role of reading information on signs and interpreting the meaning of exhibits for children (Diamond, 1986; Hilke, 1989; Taylor, 1986). Parents have been seen as a targeted audience for signage, especially in museums designed for children and their families. However, other than identifying parents as the main signage readers, family learning studies have not addressed the details of how parents make use of signage while using exhibits with their children.

This study explores the role that parent prior knowledge may have in the ways that parents use signage in a children's museum. Prior studies have addressed how the design of a museum environment interacts with what visitors bring to museums (e.g., Bitgood, Duke, & Abbey, 2006). That is, what visitors do in museums cannot be predicated only on either how museum environments are designed or on what visitors know before they visit. This premise reflects ideas from psychologists who have defined human cognition as encompassing both intellectual tools such as concepts, structures of reasoning, and the forms of discourse, as well as conventional physical tools (Brown, Collins, & Duguid, 1989; Resnick, Saljo, Pontecorvo, & Burge, 1997). Since the 1970s, many cognitive scientists have investigated how experts and novices engage differently in cognitive activities such as problem-solving or science learning (e.g., Chi & Chase, 1972; Chi, Feltovich, & Glaser, 1981). Based upon findings that compare the cognitive process of experts with that of novices, cognitive scientists have emphasized the importance of considering participants' cognitive properties to construct a full understanding of the dynamics in cognitive activity (e.g., Chi & Ceci, 1987; Roschelle, 1995).

In fact, parents in museums take a unique social position. The roles of parents in museums are not exactly parallel to those of either teachers in school settings (Hilke, 1989) or of parents in early home learning (Rogoff, 1990; Wood & Middleton, 1975). Parents in museums are likely to follow their hidden agenda, which is negotiated with children's agendas or patterns of exploration, rather than taking into account formal teaching behavior (Moussouri, 1998). Parents in a museum may not become involved with an exhibit relating to school subject-matter as much as they might with an exhibit about everyday life. As an example, Gelman, Massey, and McManus (1991) showed that parents in museums were likely to stand back if they felt lacking in relevant content knowledge for an exhibit. This finding suggests that parents in museums are not always knowledgeable mediators for their children.

Since museum researchers have begun to consider diversity in visitors' personal contexts, many studies have shown differences in learning due to prior knowledge or experience (e.g., Falk & Adelman, 2003; Falk, Moussouri, & Coulson, 1998; Swartz & Crowley, 2004). From the perspective of distributed cognition, cognitive activity can be understood by considering how participants' internal mental structures and the material and social contexts of activity interact with each other (Hollan, Hutchins, & Kirsh, 1999). Therefore, the design and content of signage, along with visitors' cognitive properties such as prior knowledge, should be considered in understanding how signage can change museum learning.

Goal of this study

This study examines the role of signage in structuring family science learning in three conditions. The conditions are created by using two different kinds of signs: content and interaction. I will explore differences in learning depending on whether families have access to both content and interaction signage, only to content signage, or to no signage. Analysis will focus on what families do with signage and the exhibits, what they talk about them, and what they learn from pre to post-test about the exhibit content.

Specifically, the following research questions will be addressed in this study:

1. How does signage about content and interaction affect parents' and children's learning? What is the role of parent prior knowledge?
2. How does signage about content and interaction affect parent-child engagement? What is the role of parent prior knowledge?

1) How does signage and parent prior knowledge affect parents’ and children’s attention to signage and the exhibit?

2) How does signage and parent prior knowledge affect parents’ and children’s use of the signage and the exhibit?

3) How does signage and parent prior knowledge affect parents’ and children’s talk in the museum?

CHAPTER 2

LITERATURE REVIEW

Prior to discussing the design of the study, literature will be reviewed in order to discover answers regarding how children and their families can have successful science learning experiences in museums. To meet this goal, first, this review will point out how museums can be unique contexts for family science learning based on how learning science is approached in today's science education. The second section will address why this study particularly investigates the function of signage as an external tool for creating museums as a family learning context. In the last section, the necessity to understand the function of signage along with parents' prior knowledge as cognitive properties of major signage readers in museums will be discussed.

Museums and Family Science Learning

Parents often simply differentiate learning in museums from that in schools because they believe their children learn through object-based, hands-on learning experiences (Melber & Abraham, 2001). Beyond a visitor's simple focus on the type of learning experience, museum learning researchers have investigated the features of a museum learning context distinctive from those of the school learning context by addressing issues such as why people visit museums, how people make meaning in the informal setting, and how the physical environment influences learning

(Schauble, Leinhardt, & Martin, 1997). For example, Falk and Dierking (2001) developed a model that explains interactive learning in free-choice contexts by considering how the personal, social, and physical contexts of museums interact with each other and affect learning.

However, despite the fact that most museums are content-based educational institutions, much of the informal learning research focuses on general learning processes. Little effort has been applied to understanding museums as a place where people can meet the worlds of science, art, history, etc. Although the general learning process in museums has been one way to easily differentiate museum learning from school learning, the uniqueness of museums as a learning context should also consider the content upon which the museum is based. Through reviewing the literature of science learning and of museum learning, this section will explore how museums can be unique science learning contexts for children and their families.

Defining learning science

For a long time, science education focused on teaching science knowledge in the form of facts and concepts to students. A student's achievements in science were determined by how many facts and concepts he or she could acquire. In this model, students had to memorize and understand a scientist's account of "science" based upon a teacher's explanation rather than through their own experience. Many studies indicate that problems of knowledge acquisition-based science education are demonstrated by student's frequent failure in transferring their understanding of one context into another context (e.g., Pea & Kurland, 1984). Thus, there has been lengthy discussion on how to support children's transfer of knowledge across problems, context, and domain (Perkins, 1993; Perkins & Salomon, 1988; Salomon & Perkins, 1989).

Many cognitive psychologists have demonstrated that knowledge is often distributed and situated in a learning context (e.g.,Hutchins, 1995; Lave, Murtaugh, & de la Rocha, 1984). In particular, Lave et al. (1984) argued that human cognition does not work independently inside the mind; instead it is situated in the context where it works with other kinds of distributed cognition. By investigating strategies for grocery shopping, they showed that people do not use arithmetic in the supermarket in the way school children answer arithmetic questions. This study showed that people often see the activity of grocery shopping as a routine chore and as a result, make habitual purchases. Supermarkets as the context of activity also affect shoppers' decision-making process. That is, a grocery shopper's decision making does not solely depend on the arithmetic calculation for the most economical purchase. In addition, the study also proved its argument by showing no correlation between arithmetic test performance and the frequency of grocery-shopping arithmetic. Thus, it has been emphasized that human cognition needs to be understood in the authentic contexts in which it is used. This unit of analysis must incorporate contextual features beyond the individual cognition or action.

If learning is the result of situated cognition, then whether or not people learn cannot be discussed in terms of performance in decontextualized settings. Instead, learning should be defined by how people change their participation as members of the communities of practice where they are actively engaged (Lave & Wenger, 1991). Put differently, learning is understood as "becoming" and knowing is seen as "doing," rather than having some fact or piece of knowledge (Lave, 1996). That is, learning and acting are not separately understood because learning is occurring through acting in situations where concepts and culture are embedded. Through learning in practice, people come to see the world in the way that people in the practice do, as well as adapting to the culture of the community of practice. Thus, learning of disciplines has been seen as a form of enculturation (Brown et al., 1989).

Consistent with this perspective, science learning should not be conceptualized by the quantity of science facts students can recite. Instead, learning should be measured by how much students change themselves as members of the community of science practice. Many science educators have tried to innovate through providing authentic experiences reflecting the culture of the practice of science to students in the classroom. Many studies have examined how students change their use of concepts, skills, and language within authentic learning contexts where they can confront their own problems and solve them through collaboratively engaging in scientific inquiry activities. As an example, Rosebery, Warren, and Conant (1992) looked at how English as a Second Language (ESL) students' use of hypotheses, experiments, explanations, and content knowledge was changed through collaborative scientific inquiry. They demonstrated that sixteen ESL students from junior high and high school showed more appropriate use of scientific ways of knowing, thinking, and talking in their reasoning for ill-defined realistic problems after engaging in a water investigation activity throughout a school year.

According to Brown et al. (1989), students need to be guided in learning how to use concepts and skills as cognitive tools in order to see themselves as active members of a community of practice (Collins, Brown, & Newman, 1989). This learning should occur in contexts where students can engage in discourse practice consistent with the community. Opportunities to learn about how to appropriate talks and language are also a critical component of understanding the culture of the practice (Rosebery, et al., 1992). Based upon these assumptions, how children are socialized into the scientific way of understanding the world should be the way to define learning science. Learning science in this context means knowing how people use concepts and skills in practice and how they engage in discourse practice like that of scientists.

From this perspective to define science learning by "doing" and "becoming," museums could be more supportive science learning contexts because visitors can more often learn through engaging in activities reflecting the practice and culture of science. Visitors in museums can experience how to use concepts and skills through manipulating exhibits consistent with scientific practice and how to talk about science through a shared meaning making process. According to Dreyfus (1984), the difference between novices and experts is found in how actively engaged they are in taking responsibility in the community of practice. That is, as a novice moves her participation in the community of practice from the periphery to the center, she can become an expert in a given practice (cited from Boaler, 2002). The openness to inviting a wide range of visitors allows museums to provide chances for children to participate in the community of science practice in their early lives, although they may start as novices. In the following section, how children have the opportunity to become empowered members of practice in science will be discussed.

Museums as the family science learning context

Many studies show that children are more capable of learning science than previously thought (DeLoache et al, 1998; Siegler, 1997). Today, not only children's museums, but many discipline-based museums also pay attention to how to introduce children to science, technology, and many other fields (e.g., Rennie & Johnston, 2004; Rennie & McClafferty, 2002; Rudy, 2004; Semper, 1990). Museums have functioned as learning contexts that provide opportunities for children and their families to become deeply involved in the practice of science. If so, what makes museums particularly beneficial in science learning for children and their families?

Museums as a learning context that merges everyday context and the science practice

According to Vygotsky (1986), children develop two different kinds of concepts, everyday concepts and scientific concepts. Everyday concepts are intuitively developed through children's perceptual experience of phenomena in everyday contexts. On the other hand, scientific concepts are formed in formal educational settings as children engage in the mental process of changing everyday concepts into generalized forms that relate to other concepts. In fact, in the traditional educational setting, everyday concepts have often been regarded as learning obstacles that inhibit learning of sophisticated disciplinary concepts. Yet many cognitive psychologists have indicated that these everyday ideas and ways of thinking are not necessarily different from those used in disciplinary practice and could be aligned with the disciplinary practice and used as productive resources (e.g., diSessa, 1993; Minstrell, 2001; Moll, 1990, 2001; Smith et al., 1993).

Based upon today's sociocultural perspective, Moll and his colleagues (Moll, Amanti, Neff, & Gonzalez, 1992; Moll & Greenberg, 1990) argued that everyday concepts and scientific concepts mutually affect each other. That is, everyday concepts could be the "conceptual fabric" for the scientific concept as it is connected or transformed. Also, scientific concepts could be more meaningful and significant for learners when connected to personal experience. As an example, Moll et al.'s (1992) study showed that children could be active learners and successfully learn in contexts where their everyday knowledge, the "fund of knowledge," is respected. In this study, ten teachers were involved as researchers to investigate their students' household knowledge and they implemented this knowledge for their later instruction. These teachers served as mediators between their students' families and the school. As a result, children in the classes where their everyday knowledge was reflected could better understand scientific inquiry methods, which they had often failed to learn before.

Unlike formal learning contexts that often isolate learners from their own personal contexts, museums are contexts where people bring their everyday understanding and experiences. Learning in museums is not constrained by what museums provide to visitors; rather, it occurs through a dynamic interaction between the everyday knowledge and learning processes of visitors, and the disciplinary practices of museums. For example, studies focused on family learning in museums have shown that a large percentage of families' conversations were linked to prior knowledge and shared experiences (e.g., Ash, 2003, 2004; Taylor, 1986).

In particular, Ash (2003) observed how family members in a museum talked to each other about adaptation. Families in this study often brought up their own variations on the theme, which were related to adaptation, and constructed meaning together through use of various dialogical strategies (e.g., questions, explaining, interpreting, etc.). Based upon this finding, Ash argued that the distributed expertise among family members and the museum demanded a dialogical negotiating process that becomes the learning moments for family members. That is, visitor's meaning making is not limited to the physical context of the museum. Museum visitors actively and spontaneously engaged in meaning making by connecting new experiences in museums with what they already knew and what they had seen, heard, read, or done. In a follow up study, Ash (2004) targeted Spanish-speakers' learning at an aquarium and pointed out that families also brought their own learning strategies. In this study, Spanish-speaking parents often sought information actively through questioning the available experts, thus showing their children how to get information, instead of just depending on written information from labels. Ash argued that people also brought such strategies for making meaning in a museum from their everyday contexts.

Museums are particularly beneficial for children to learn science in that they provide opportunities for children to naturally engage in the practice of science. According to Gardner (1991), museums are valuable learning contexts for children because they support children's deep involvement in a discipline in a way that meshes with their everyday context, not just because a museum's atmosphere is an open one. He argued that learning in museums, which is based on an apprenticeship model, could be the channel for exposing children to expertise in the various disciplines before they start school. Since the hands-on approach has been favored in museums, learner's active engagement with exhibits has been one of the important characteristics of museum learning (e.g., Paris & Hapgood, 2002; Ramey-Gassert et al., 1994).

By allowing visitors actively engage in their own learning, museums have invited a wide range of visitors, including children, into the world of disciplinary practice. Museums have appealed to the public as a place where visitors can be empowered to engage in the deep and rich level of disciplinary domain without fearing failure (Adams & Moussouri, 2002).

According to Lewin (1989), museums are “the coupling of a realistic setting with the use of objects which belong in that setting and which therefore can be experienced in contextually relevant ways (p. 53).” That is, exhibits as museum objects, which are developed based upon the disciplinary practice, are things that invite children to play, but also things that help children learn. These hands-on objects help children to engage in practice without being estranged. Museums can be the educational environment that supports children who might begin to engage in their learning from the way that they usually engage in the everyday context; to move forward by appropriating a way of thinking, knowing, and talking that is aligned with practices of science.

Today, children are believed to revise or build more sophisticated concepts through challenging their everyday understanding and ways of thinking, which originate from their own experiences. Semper (1990) indicated that the museum is a place where people can learn through testing out what they believe by providing opportunities for examining previous knowledge and experience. In effect, the museum merges everyday worlds and disciplinary worlds. Roschelle (1995) found many possibilities in museums as the context to resolve contradictions between everyday and scientific concepts. The museum could be a space that bridges children’s knowledge and ways of engaging in the everyday world with the knowledge and ways of engaging in the practice of science. In this way, children in museums can meet the worlds of science without being intimidated. The reason that a museum is meaningful, especially for children, is that it reframes the disciplinary practice and approaches to be more like everyday activity. This makes the disciplinary learning experience easily extended to children's everyday life and later, perhaps, to school learning.

Museums as unique social learning contexts

Not only do museums link everyday contexts with discipline-specific practice, but they also link people to learn together. Museum visitors learn through interacting with one another rather than through learning alone. Generally, children visit museums as members of social groups such as a family. They engage in activities with their parents or other adults. Many museum learning researchers see object-based museums as contexts in which exhibits are catalysts for both children and parents to engage simultaneously in novel learning experiences (e.g., Borun, Chambers, Dritsas, & Johnson, 1997; Ellenbogen, Luke, & Dierking, 2004).

Because families make up the majority of visitor groups, investigations of how children learn through interacting in social contexts mostly focus on family learning (Dierking & Falk, 1994). Thus, many museum studies target the family as the learning unit. In particular, many family studies have investigated how parents take a role in shaping children's museum experiences and show that parents indeed enrich children's museum experiences (e.g., Crowley & Callanan, 1998; Diamond, 1986; Taylor, 1986). Through tracking parent and child engagement in exhibits, Crowley and Callanan (1998) showed that children were more likely to be engaged in the experience that the museum intended and had a more powerful experience when children engaged in activities together with their parents. Diamond (1986) showed that parents helped children, who were more likely to focus on what they did and what they saw through touching and manipulating museum objects, by sharing symbolic information gained from reading labels or from previous experience. In Taylor's (1986) study, parents reminded children of previous experiences and built meaning together with their children (cited from Dierking & Falk, 1994).

According to Guberman (2003), parents can be the most appropriate helpers for children in understanding museum experiences because they know what kinds of experiences and knowledge children have built in an everyday context (cited from Ash, 2004). Through studies observing parent-child talk with families using hands-on science exhibits, Crowley and his colleagues showed that parents provided simple explanations to their children in more than one-third of parent-child interactions; however, they pointed out that parents used a simple, short and fragmented form of explanation (Crowley et al., 2001a; Crowley, Callanan, Tenenbaum, & Allen, 2001b). Nevertheless, Crowley and Galco (2001) indicated that although parent explanations in museums are not complete scientific explanations, they still could be powerful because they are provided at the moment of joint parent-child attention in the contextualized shared situation.

The uniqueness of museums as social learning contexts for children is not simply true because children learn through interacting with parents or others. After all, children also learn through interacting with teachers or peers in school. Instead, museums can be differentiated from the formal school setting given that in museums children have the authority to choose what, when, and how to learn. Many researchers based in the situated learning perspective have indicated that the authority of learning in formal education is given to the curriculum and the teacher, not to the student (Boaler & Greeno, 2000). Students have to learn the curriculum and what teachers have planned for them under the assumption that others know what and how they need to learn. In contrast, children are more empowered in museums through having a sense of control over the learning process.

In fact, a parent's role in museums does not necessarily parallel that of a teacher in school. According to Hilke (1989), families are a very flexible learning system. Based upon observation of family activity in the museum, Hilke pointed out that a parent's agenda for teaching or learning is negotiated with the child's agenda. In museums, parents usually shape children's experiences through calibrating their agenda with their child's, rather than through using formal teaching behaviors. Hilke's observations showed that often, parents allowed children to seek their own interests so that children were more likely to initiate and terminate their engagement with exhibits in the museum. Following children's exploration, parents engaged in their children's learning process through transferring information concerning the exhibits with more interpretive and informative comments. That is, parents followed their "hidden agenda" (p.127): They invisibly facilitated children's learning throughout the museum visit rather than dominating the interaction and following a parental teaching agenda.

Both parents and children take unique positions in the museum. In museums, parents do not like to direct children's learning processes like teachers in school because they expect their children to have different kinds of learning experiences. According to Lewin (1989), in museums parents should take a role as interpreter and co-learner, rather than as presenter or teacher. According to Hilke (1989), children and parents prefer to think of each other as an interactive partner. Thus, museums are contexts where children are motivated to learn because they have autonomy and responsibility for their learning, rather than being controlled by others (Csilkszentmilhalyi, 1979; Csilkszentmilhalyi & Hermanson, 1995). Many learning researchers indicated that children can engage in discipline-specific activities when appropriate levels of guidance are given (e.g., Brown et al., 1997; Simon, 2001). Children construct meaning and engage in discourse practice with their parents in museums. Museums create a learning context where parents can be involved in children's learning without undermining children's autonomy and responsibility for their learning. Thus, a museum where children can engage in disciplinary practice with support from their parents is a beneficial learning context for children.

Signage and Museum Learning

Since the function of museums as the educational context has been emphasized (Ames, 1988; Bierbaum, 1988), there have been methodological innovations in investigating how people learn in the interactive museum. In the early stage of museum studies, research often tracked visitors' behaviors to describe how visitors learn (e.g., Diamond, 1986; Hilke, 1989). Since "conversational elaboration" (Leinhardt, Crowley, & Knutson, 2002) is defined as the learning process in museums, visitors' conversation or talk came to be spotlighted as the window to look into how people learn in museums (e.g., Crowley et al., 2001a; Allen, 2002). Today, learning in museums is defined as the meaning making process which is achieved through negotiation and interaction between visitors and tools. More dynamic and multiple modes such as gesture, talking, and action for using tools in a museum is emphasized for an understanding of how people learn in museums (Rahm, 2002).

Today, many of cognitive scientists' explanations of how humans think and learn do not solely depend on individuals' internal mental activities. By considering how a human's cognition is interacting with social others, a mediating artifact, and the environment, cognitive scientists have argued that cognition is distributed beyond the individual to an outside individual (Baetson, 1972; Greeno, 1997; Hutchins, 1995; Resnick et al., 1997; Salomon, 1993). From this perspective of distributed cognition, it has been argued that cognitive processes are socially distributed between people and that cognitive processes are bound to the material structure of cognitive activity (Hollan et al., 2000). Based upon reviewing literature that takes the perspective of distributed cognition, the following section will discuss what kinds of studies are asked to make use of signage as a tool for enhancing visitors' meaning making in museums and how to design signage to empirically examine its role in a museum.

Signage as a tool for structuring museum activity

In a museum as the object-based learning context, signage has been used to provide information which may not be explicitly delivered through the exhibits to visitors (Bitgood, 1996; McManus, 1989; Serrell, 1996). In particular, museums put the educational contents of their exhibits on signage, seeing signage as a tool to communicate that content to visitors. Nevertheless, according to Thompson and Bitgood (1989), the large number of factors that affect visitors' signage reading has been an impediment to the conduct of empirical studies investigating how signage is used in a museum context and how to design effective signage for visitors' learning. Because of the lack of guidelines based on empirical data, designing effective signage has been seen as a difficult task in the museum field.

Often museum researchers have admitted that people come to visit museums to interact with the exhibits as three-dimensional visual experience, not signage as two-dimensional graphical panel (Bitgood, 2003). By tracking visitors' memory of their museum visit, museum researchers proved that visitors are more likely to focus on the exhibits and to interact with them as the main objects of museum experience (Bitgood & Cleghorn, 1994; Stevenson, 1992). Low signage reading rates actually have been reported in several studies (Brennan, 1977; Bitgood et al., 1986). However, it has been argued that successful museum learning experiences often correspond to visitors' successful communication about educational contents of signage along with their exploration of exhibits (Borun & Miller, 1980; Diamond, 1991). By listening to visitors' conversation instead of depending on the observation of visitors' actions, McManus (1989) showed that text of signage is often echoed in visitors' conversation, and he thus disputed the claim that visitors were reluctant to read signage in museums. The importance of signage as a communicative tool has been raised for supporting visitor's learning in museums (Serrell, 1996; Schauble et al, 1996).

Seeing signage as an important tool for supporting visitor's learning expedited museum researchers to investigate how to increase visitors' signage reading rate in museums. In particular, Bitgood and his colleague have looked into the factors affecting a visitor's attention to signage from the perspective of environmental psychology. For example, Cota and Bitgood (1993) showed that visitors recall information more easily when information is given in shorter text. Bitgood, Benefield, and Patterson (1990) showed that where to install the signage is a critical factor that affects visitors' signage reading. Bitgood et al. (1992) showed that signage reading behavior could be encouraged by handouts asking questions that can be answered by signage at a zoo. Based upon findings from several studies looking into visitors' signage reading behaviors in museums, Bitgood (1996; 2003) proposed that signage could be better read when designed to be distinctive from other stimuli on the museum floor (e.g., font size of text, contrast with setting background, multi-sensory characteristics, etc.), when it could successfully motivate visitors to read by minimizing efforts to read (e.g., through decrease in the number of words per chunk, proximity of label to object, etc), and when it can provoke visitors' interest or thought (e.g., by asking questions, confronting and correcting questions, challenging reader, etc).

However, getting attention from visitors is not sufficient to guarantee the effect of signage on visitors' learning. Effective signage must be designed not only to get visitors' attention and make them read, but also to successfully encourage visitors to communicate signage content to understand how that content should be considered. Therefore, later signage studies started to examine the effect of signage on visitors' content or conceptual learning by measuring knowledge gain or memory of the signage content beyond simply observing visitors' signage reading behavior (e.g., Falk, 1997; Litwak, 1996). For example, Falk (1997) examined the effect of explicit labeling of exhibit clusters on visitors' comprehension of specific concepts and understanding of the bigger idea. He showed that visitors who visited exhibits with explicit labeling of exhibit clusters learned more about the specific concept of exhibits and were better able to describe the bigger idea of the exhibitions. Litwak (1996) examined the effect of using questions as titles on getting visitors' attention and promoting learning. In this study, Litwak showed that questions were more effective for visitors' memory of signage text than were standard statement titles, regardless of whether the questions are cued to be tested, or whether they are exposed in different lengths of signage text.

Since the perspective of distributed cognition has adapted to understand visitors' learning in the museum field, it has emphasized that visitors' learning needs to be understood as a meaning-making process through negotiation and interaction between visitors and tools. Many museum studies have looked into how the exhibit as the main meaning-making tool affects visitors' meaning-making processes as learning in a museum (e.g., Rahm, 2002). However, there has been little progress in studying signage as a tool for visitors' meaning-making process. Previous signage studies focusing on visitors' attention to signage or on learning outcomes such as an individual's knowledge gain or memory recall are limited to addressing how signage as an external tool functions for structuring a museum activity. Therefore, in order to understand how signage particularly functions as a tool for supporting visitors' meaning-making process in museums, it is necessary to take a close look at how signage is used in the cognitive processes of museum learning along with usage of the exhibit.

How did previous literature study and discuss the function of tools in human cognitive activity? From the perspective of distributed cognition, in order to understand how cognitive system plays out in the social and material world, cognitive actions should be carefully tracked in the context of activity (Hollan et al, 2000). The extensive observation using many techniques such as participant observation, video and audio recording, and interviewing have been seen as the appropriate ways to identify features of the interaction between people and tools in an activity. Based upon this perspective of distributed cognition, there have been efforts to explain how tools function in human cognitive activity (e.g., Cole & Griffin, 1980; Hutchins, 1990; 1995).

First, Cole and his colleague argued that the function of tools could be found in amplifying the cognitive ability of the users (Cole & Griffin, 1980). In particular, they indicated that a tool itself can act like an intelligent agent in an activity system and allow people to do things that they could not do without it. For example, Griffin, Belyaeva, and Soldatova (1993) focused on how computer programs play a role in enhancing children's learning. They identified the role of the computer as learning medium in enhancing the social negotiating process between adults and children and allowing programmers to join in participants' communicative interaction to constitute learning context. And they argued that mediated negotiations using a computer, among child, adult, and programmer as the hidden member, may support children to learn better. Second, Hutchins (1990, 1995) also explained how the external media functioned in the navigating process through the extensive observation of cognitive processes of ship navigation. He demonstrated that tools like the nomogram, which is designed for easily computing the relation among distance, speed, and time, allow people to do things that they are good at by taking over the computational process. Based on this observational data tracking the cognitive processes of tool using, Hutchins indicated that external tools transform a task for people to get to the answer or to the path where solutions are apparent.

From this perspective of assuming that cognition is distributed across the material and social world, how could the function of exhibits and signage be explained as the external tools structuring museum learning activity? In fact, this is not an easy question in that how a tool functions seems to depend on how and with what purpose it is designed. Although both Hutchins and Cole and his colleague agreed that tools amplify the cognitive abilities of the task performer, there still seems to be a difference in the way to approach identifying the role of tools in a cognitive activity. In Hutchins' study, he focused on tools such as a nomogram that navigators know how to use and on why they need it to perform a task. Therefore, navigators who use the tool do not have to negotiate how to use it or what to do with it to perform their task. On the other hand, Cole and his colleague focused on a tool more likely to act as an intelligent agent in the activity, rather than on one passively used to affect a cognitive process. That is, Cole and his colleague were more likely to focus on a tool whose function is negotiated, not pre-defined.

In previous literature, signage is often described as a tool encouraging social interaction among visitor groups (Serrell, 1996). Screven (1992) pointed out that museum signage could conceptually orient visitors so that visitors interpret the exhibit. However, these identified functions of signage have not been empirically examined. In addition, little is known about how the usage of signage as a complementary tool for the exhibit is related to exhibit usage. In a previous signage study, Bitgood and Patterson (1993) showed that signage readers were more likely to engage with the exhibit longer than were nonreaders because signage reading time usually does not conflict with exhibit viewing time. However, this study is still limited to describing the dynamics of using two museum objects for meaning making, as it focused only on the time to use the exhibit. Therefore, it is necessary to take a close look at how signage and the exhibit are used as external tools by considering actions to use signage or talk about it, in order to understand signage as a tool for structuring learning activity in museums.

Designing signage as a tool for family learning

In the earlier traditional museum context, visitors mostly made meaning by watching objects, sharing knowledge, and reading signage (McManus, 1989). Signage, which often takes an anonymous museum voice to provide the educational message of an exhibit, was the only channel for museums to explicitly communicate with visitors to support visitors' meaning making (Bitgood, 1996, 2003). However, since museums have developed more interactive context, museums do not solely depend on signage as the communication medium. Through directly touching and manipulating exhibits, visitors collect the evidence for interpreting what the exhibit intends to communicate with visitors. Changes in museums' physical environments have required different signage content and design. Serrell (1996) emphasized that the contents or designs of signage have to be developed differently by different types of museums.

In fact, signage is not only an artifact that museum researchers have to understand; it is also a tool for changing the museum field. Therefore, signage is also important to approach from an engineering perspective in order to practically implement signage in educational contexts, besides understanding the specific cognitive function of signage from a scientific approach. According to Hollan et al. (2000), design aspects need to be examined through experimental studies in order to implement the understanding of how cognition is distributed across people and tool(s) for creating better contexts for working or learning.

If so, in order to implement signage as a tool for family science learning in a museum, what kind of content and design should be considered? Recently, in the article that summarized the lessons from running a learning lab in a Children's Museum through collaborating with exhibit designers and museum educators, Knutson and Crowley (2005) pointed out that a museum may consider two types of signage contents, the *disciplinary content* and the *interaction scaffolds*, for creating better family learning context. Given that visitors often miss the learning opportunities embedded in exhibits, first, Knutson and Crowley indicated that visitors need to be encouraged to see what kinds of learning opportunities they can have from signage. By informing visitors about learning opportunities in the exhibit, using disciplinary content, they insisted that museums can help visitors to engage with the exhibit in a more enriched meaning-making process beyond doing and seeing. Visitors' meaning making from the exhibit could be more contextualized to the discipline. Second, they argued that the *interaction scaffolds* could help visitors easily structure the goals for a task and what needs to be done to achieve those goals. That is, allowing visitors to adopt the text on the signage instead of letting them infer what the activity is for and what to do to achieve activity goals may help visitors easily engage in the way that exhibit designers intended. In particular, parents in museums could be supported to have ideas about how to initiate the activity and interact with their children for a shared meaning-making process.

Beyond emphasizing the necessity of different content and form of signage for the interactive museum context, Knutson and Crowley (2005) suggested what kind of signage contents in specific are needed and how these two types of signage content need to function to support family learning in a museum. However, it is not yet resolved how these two types of signage content should be designed to be successfully implemented in the family learning context. Previous museum signage literature focusing on suggesting practical guidelines for designing physical characteristics of signage to increase signage reading rate (Bitgood, 1992; 1996) offers no insight into how to design these two signage contents to achieve their hypothesized function.

Since the computer has come to be seen as an effective tool for learning, many studies have investigated how to design an interface between computer and computer user in order to facilitate constructive learning (e.g., Griffin et al., 1993; Mayer, Sobko, & Mautone, 2003; Moreno, Mayer, Spires, & Lester, 2001). In particular, Mayer and his colleagues developed social agency theory to explain how learning processes differ according to what kind of communication schema is activated (Atkinson, Mayer, & Merrill, 2005; Mayer, 2001). According to them, learners can interpret learning episodes from computers in two different schemes, either social conversational schema or information delivering schema: First, social conversational schema is activated when computer users interpret the learning episode from a computer as the conversational process. Once social conversational schema is activated, learners are more likely to act as if they are in conversation with another person. That is, once human-to-human communication rules (human conversational exchange) come into play in the human-to-artifact (computer) communication, it helps learners to make sense of the message that the artifact tries to provide through engaging in deep cognitive processes such as *selecting* relevant information for further processing, *organizing* the pieces of information into coherent representations, and *integrating* verbal and visual representations with each other and with prior knowledge. Second, the researchers indicated that computer users do not actively engage in deep cognitive processes when learners interpret the learning episode as a case of information delivery. That is, as computer users activate a rote learning approach, computer users often engage in simple cognitive processes like *selecting* and *encoding*.

Then, what do these computer interface studies based on the social agency theory suggest for designing museum signage for family learning? In fact, computers and exhibits create very different learning contexts. However, common ground is found in that both computer interface and signage are intended to mediate the communication between artifact and users. That is, the exhibit is an object that learners mainly interact with just as computer users interact with a computer. Signage can be parallel with texts or voices in the computer program for communicating about the educational message in Mayer’s studies. Therefore, by putting signage in a parallel line with computer interface, the social agency theory can be adopted for developing museum signage.

Then, as social agency theory suggests, signage could be designed to create a social conversational mode for active, communicative negotiation among parents, children, and exhibit designers (or signage writers) so that families engage in active meaning making processes rather than in passively encoding information. One way to create a social conversational mode between the computer and its users in Mayer and his colleague's studies, based on the social agency theory, is by using pedagogical agents. For example, Moreno et al. (2001) examined how a student's learning process was more actively stimulated by the effect of the animated pedagogical agents in the computer-based learning environment. They then showed that students who engaged in their learning in the conversational mode with the social agency were more likely to perform better across retention tests, interest rating, and transfer tests after taking multimedia lessons in how to design plant parts to make them survive in various environments. In the following study investigating the effect of a speaker's voice of narration, Mayer et al. (2003) confirmed the social agency theory's hypothesis by showing that students learning from familiar voices (standard accent, human) performed better in their learning test than did other students hearing unfamiliar voices (foreign accent, machine synthesized). Moreover, the effect of using a character on learning behavior was also shown in a museum study. According to Crowley (2001), adding a girl character on museum signage affects how families talk in a museum. Parents, who were less likely to provide explanation to girls than to boys at the science related exhibits in their previous study (Crowley et al., 2001b), were successfully encouraged to explain more about the science to girls.

In the current study, based upon this previous literature, two types of signage content will be designed to create a social conversational mode with families: As the first type of signage content, content signage will be developed for supporting visitors to easily catch the educational message that the exhibit designer particularly intends for visitors to learn. For this goal, explanations to help visitors' identification of the exhibit and interpretation of the exhibit's features and evidence will be provided by using the voice of a mechanic character to create a social conversational mode, rather than using the anonymous museum voice of traditional museum signage to simply focus on delivering information. Second, interaction signage will also take the voice of a mechanic character to prompt visitors to easily figure out the goal of the task and what needs to be done to achieve that goal. In specific, by adding short questions which are answered by the exploration of the exhibit and content signage, interaction signage will guide parents to quickly figure out how the exhibit needs to be explored and what the content signage is about. By comparing the no-signage condition and two signage conditions created by the above two types of signage content, this study will examine how signage functions as a meaning making tool and affects what families learn and how they engage with the exhibit.

Parents as Children's Learning Partners in Museums

From the perspective of distributed cognition, cognitive activity is a continuous, renegotiated, and emergent product of interaction among mental structure, material structure, and social structure (Hollan et al., 2000). By assuming that cognitive processes are distributed across time, the perspective of distributed cognition indicates the importance of considering how the culture and history are embedded in the coordinating, negotiating process of emergent cognitive activity (Hollan et al, 2000; Pea, 1993; Salomon, 1993). It has been argued that the way to understand how the tool or artifact functions as the external structure or resources in the cognitive activity should be based upon how it is coordinated with internal structure.

In particular, according to Pea (1993), how artifacts are used for distributing cognition is mediated by culture and context, instead of depending only on the fitness between artifact and intention of the artifact user. He indicated that the variations in how people exploit means to form a system of distributed intelligence in order to achieve a task originated from the following conditions: what kinds of background experiences learners have, whether artifacts are designed to fit a learner's desire or goal, or how learners perceive artifacts as the means of achieving their goals. For example, he pointed out that a person's desire or goal for the activity mediates the interpreting process of how to use tools as a means of achieving their goal or agenda. That is, when people do not have a specific goal or intention, desire for how to use tools may arise opportunistically in the situation. In contrast to when people have a specific goal and intention, the usage of the tool will be specified for their needs. Based upon this claim, he argued that to understand how an individual uses a tool, it is necessary to understand that individual's cognitive properties.

In visitor studies, many efforts to understand the effect of environmental characteristics and of the design of physical environments are easily found from a more practical point of view for developing museums as a better learning context (e.g., Thompson & Bitgood, 1989; Hirschi & Screven, 1988). On the other hand, some museum learning researchers have examined in greater depth what people bring to museums and how what they bring affects their museum experience, in order to understand intrinsically how people learn in museums, as an informal learning context, in contrast to how they learn in schools, as a formal learning context. In particular, visitors' personal contexts such as prior experience and knowledge, or agenda, etc. have been highlighted as one of the important contexts for understanding museum learning along with social and physical contexts (Falk & Dierking, 2001).

Today's museum studies have focused on the variance in visitors' personal contexts such as prior knowledge and the goal or agenda of the museum visitor. These studies addressed what kinds of agendas and prior knowledge visitors brought to museums and how those factors affected their visit and their learning (e.g., Doering, 1999; Falk et al., 1998; Falk & Adelman, 2003; Pekarik, Doering, & Karns, 1999). For instance, Doering and her colleagues (Doering, 1999; Pekarik et al., 1999) showed that visitors' expectations, which are identified in four categories based upon experiences that visitors value in museums (object-based, cognitive, introspective, and social), affected what kind of experience they had in museums and whether or not they were satisfied with their experience. Through investigating what kinds of learning and teaching beliefs parents bring to a museum, Swartz and Crowley (2004) showed that parents are not always eager to support their children's learning. In their study, although 37% of parents saw themselves as their children's learning partner, or indicated museums as a disciplinary learning context, still, 37% of parents felt that their role in their children's learning in a museum was to step back from their child's engagement with the exhibit and to leave the child to explore or play in his or her own way. Based upon this finding, the researchers suggested that variations in parents' beliefs about learning and teaching can be an indicator of variations in families' experiences in museums.

Falk and his colleagues empirically proved that visitors' learning is affected by visitors' personal contexts. First, Falk et al. (1998) showed that the individual motivation to visit a museum impacts what and how much visitors learn at a museum. In particular, they showed that visitors who had high educational motivation had more conceptual learning, while visitors who had high entertainment motivation showed vocabulary development and overall mastery of the topic, as they were more likely to focus on the objects. In addition, Falk and Adelman (2003) showed, through tracking changes in conservation interest and knowledge among 100 visitors to the National Aquarium in Baltimore from entry to exit, that learning gains were not evenly distributed across all visitors by their prior knowledge and interest. Visitors with low to moderate knowledge and moderate to extensive interest benefited most from the museum experience.

As shown here, many museum studies have indicated how important it is to consider visitors' personal context in regard to their museum experience. However, little investigation has yet been done on how these visitors' personal contexts may be related to the usage of tools such as the exhibit or signage beyond general museum experience or learning. Recently, museum researchers started to examine the effect of personal context of visitors on the usage of signage. As an example, Bitgood et al. (2006) have proven that not only the design of signage (the number of words) but also visitors' incoming interest level is a predictor of whether visitors read the signage or not. Although the study indicated that, in comparison to signage design, visitors' interest level was a moderate predictor of visitors' signage reading; nevertheless, the research provides reasons to look into what visitors bring to museums as one factor in the study of the role of signage in visitors' learning in museums.

Based upon the current cognitive psychological perspective to define tools by including both material and intellectual tools (Resnick et al., 1997; Brown et al., 1989), the kinds of intellectual (or cognitive) tools a learner wields must be taken into account to understand how signage as a material tool functions in the cognitive process. Nevertheless, we still don't know much about which group of people is more likely to read the signage and how they use the signage content for their interaction with the exhibit. Therefore, not only design aspect or content of signage, but also visitors' cognitive properties such as prior knowledge, need to be carefully considered in order to understand how signage functions in supporting families' learning in a museum. Based upon studies investigating the role of parents in museums as primary signage readers, the following section will discuss why a parent's prior knowledge must be considered in looking into how signage is used to support family learning in museums.

Parents as signage readers in museums

In previous visitor studies literature, family has not been a targeted group in the study of signage in museums. Previous signage studies often observed individual visitors' signage reading behavior or that of adult groups, who showed more focused attention to signage and were more likely to read signage than were family groups (e.g., Cota & Bitgood, 1994). Instead, how families use signage in museums has been described in early family learning studies. In these studies, parents are identified as major signage readers who often take the role of interpreting the meaning of exhibits by using symbolic information on signage and providing it to their children (Diamond, 1986; Hilke, 1989; Taylor, 1986).

Since Vygotsky's zone of proximal development (ZPD) concept was introduced, many cognitive developmental psychologists have investigated the effect of social context on children's cognitive development. Often these studies investigated what kind of role parents take to assist children in performing a task or in learning cultural knowledge in the ZPD, which is defined as the invisible potential learning space where children can leap to learn beyond their limited ability (e.g., Rogoff, 1990). Often, these studies showed the positive effect of parents' support for early learning or cognitive development (e.g., Gauvain & Rogoff, 1989; Wood & Middleton, 1975). Therefore, parents were often described as the knowledgeable mediators in the zone of proximal development, who know about what to teach and how to teach just like "teachers in children's early life" in many of the developmental literatures.

This view of parents as knowledgeable mediators has been adopted in early efforts to investigate family in museums as a means to understand how children learn in museums (e.g., Crowley & Callanan, 1998; Fender & Crowely, 2007; Moussouri, 1998; Gleason & Schauble, 2000). These family learning researchers have demonstrated that children learned better by having parents' support. First, Crowley and his colleagues have shown that children had a more powerful experience when they engaged in activities together with their parent (e.g., Crowley & Callanan, 1998; Crowley et al, 2001a; 2001b; Crowey & Galco, 2001; Eberbach & Crowley, 2005; Fender & Crowley, 2007). In their studies, more than one-third of parents' conversation with their children was provided in the explanation, although it often takes a simple, short, and fragmented form. Through several studies, they proved that even parents' incomplete form of explanation, the so-called explanatoid, can still support children's learning because it is provided at the moment when parents' and children's attentions are joined in a contextualized and shared situation. Based on these findings from family learning studies in museums, which particularly focused on the impact of social-interaction on children's learning, parents in museums are often assumed as knowledgeable mediators who are capable of playing a role similar to that of teachers in schools.

However, Gelman et al. (1991) argued that parents may not always be knowledgeable mediators for their children by showing that the content of the exhibit made a difference in the level of parent involvement in the exhibit domain. In this study, Gelman et al. compared parent involvement in their children's activity in two different exhibits: a grocery store and an exhibit about number concepts. They demonstrated that parents were less likely to engage in their children's activity in a museum when the activity was particularly related to school subject-matter such as science or mathematics. That is, while parents in the grocery store exhibit actively prompted and requested their children to do something (45.5% of all coded behavior), the majority of parents in the math exhibit did not actively interact with their children by standing back and allowing their children to engage alone. Gelman et al. discussed this finding considering the possibilities that parents felt lacking in competency in the subject matters or that they did not think of teaching the subject-matter content as their role.

Considering the variance in parents' knowledge in the exhibit content, parents in museums may not be in an exact parallel position with parents helping with children's learning of early, everyday concepts or of simple problem-solving tasks (e.g., Saxe, Guberman, & Gearhart, 1987; Wood & Middleton, 1975). This suggests that how parents make use of signage as a tool to make meaning of the exhibit and how they take a role as their children's learning partners could be different by how much parents are confident about or familiar with the content of the exhibit. In fact, since the 1970's, cognitive studies aimed at understanding how people learn, have shown a research trend to compare ways in which experts learn or solve problems differently from novices (e.g., Chi & Chase, 1972; Chi et al., 1981). These studies have revealed that experts are more likely to detect and recognize the features or deep structure of a problem, to monitor cognitive processes, and to choose more appropriate strategies for problem-solving or for learning than do novices (Chi, 2006a; 2006b).

Based upon these previous literatures, this study will examine the effect of prior knowledge of parents, as main signage readers, on parents' engagement with their children. Although parents' knowledge of the content of the exhibit is different from a construct which was explained by wider criteria such as what kind of cognitive strategies they apply for the cognitive processes, the expert-novice research trend still provides a reason to consider how familiar and knowledgeable parents are with the domain of the exhibit for understanding the role of signage. Previous museum studies also suggest that visitors' prior knowledge is a simple measure and a factor that can affect how they use signage as a tool for meaning making in museums. Lastly, given that contents of the exhibit as one type of signage content used in this study could overlap with what parents know about the exhibit, the differences in using signage by parent's prior knowledge is somewhat expected. This expectation raises the necessity to examine how differently parents with better knowledge about the exhibit may make a use of signage than may parents who are unfamiliar with the domain of the exhibit.

According to Lewin (1986), museums, particularly museums for younger children, have not yet developed "ways to help parents learn how to use the museum to enhance the intellectual, emotional, physical, and social development of children (p. 71)". She then argued that museums can be more effective learning spaces when parents understand how the museum space is created and when parents are involved in creating a better learning context. Moreover, a museum is not just a learning context for children; rather, as a life-long learning institution where everyday context is merged with scientific practice, a museum is a context in which parents also could learn science along with their children. Lewin's argument was made 20 years ago, but it seems that not much progress has been made in studying the way to support parents as "children's learning partners" and "life-long learners" in the museum field. Therefore, more systematic studies are required to investigate what kinds of difficulties parents have in museums and how parents' difficulties could be intermediated so that parents can truly be their children's learning partners and can also be life-long learners in museums. In order to find a more practical way to support a wide range of parents in museums, this study will look into how parents make use of two meaning making tools—signage and the exhibit—along with considering what parents bring to museums.

CHAPTER 3

METHODLOGY

Participants

Forty-five parent-child dyads with children aged six to seven years were recruited at the Children's Museum of Pittsburgh while visiting the Garage Workshop exhibition area where the target exhibit is located. Fifteen parent-child dyads were assigned to three different signage conditions: 1) Content and interaction signage condition; 2) Content signage condition, and 3) No signage condition. Children's mean age was 7.2 years-old (SD=.7 years-old) in the content and interaction signage condition, 7.1-years-old (SD= .8-year-old) in the content signage condition condition, and 7.2-year-old (SD= .8-year-old) in the no signage condition.

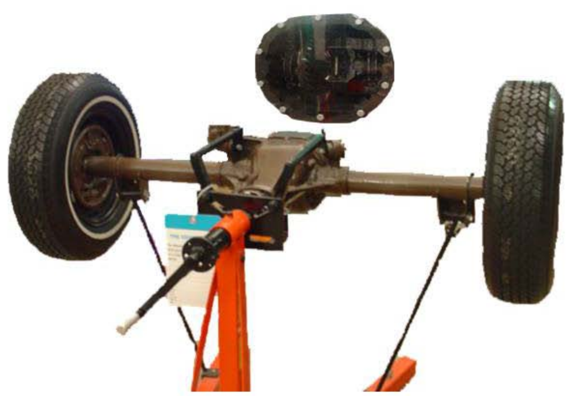
Given that the domain of the target exhibit, how cars work, might have been linked to gender differences in parents' prior knowledge, children and parents' gender were evenly distributed in three conditions: Seven boys and eight girls were assigned to all three conditions. Seven fathers and eight mothers were targeted in each condition. Eleven parent-child dyads in each condition were weekday visitors to the museum and four parent-child dyads were weekend visitors. Data collection lasted until the target number for each parent knowledge group [seven parents with high knowledge and eight parents with low knowledge] was reached[1].

Experimental setting

An exhibit about the engine and an exhibit about the differential were selected as targeted exhibits. The engine and the differential are displayed on the museum floor as they are laid out in a car; the exhibit allows visitors to operate and see how inner parts such as pistons and gears work (see Figure 1).

Figure 1: Two car parts exhibit

Engine



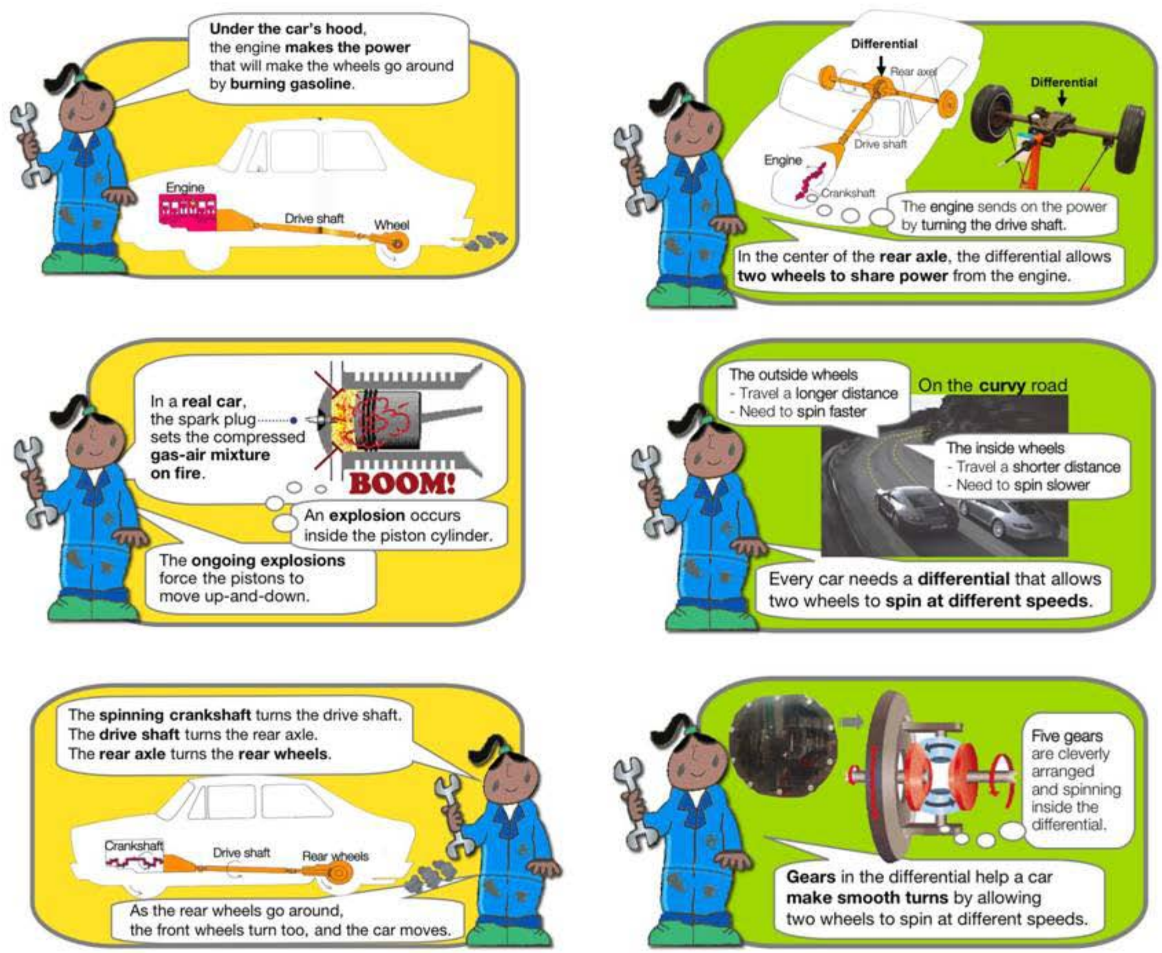
Differential

In order to create the three experimental conditions, two types of signs were developed, content and interaction signs.

Content signage for two car parts

Content signage explained where the engine and the differential are inside of a car, what the functions of both are, and how the inner parts of the engine (e.g., piston, crankshaft) and the differential (e.g., gears) work. Based upon previous studies that indicated that signs are more likely to be read when visitors are able to look at the exhibit and signage at the same time (e.g., Bitgood, Benefield, & Petterson, 1990), the content signs about each car part were printed in three pieces of signage panel and installed on each exhibit in order to allow visitors to see the information while they were using the related exhibit part (see Figure 2).

Figure 2: Content signage



For instance, the content signage that explains that explosions make pistons move up-and-down was installed under the window through which visitors could see an exposed piston. The sign about how the crankshaft transforms up-and-down movements of pistons into a spinning motion was installed under a cut-away window on the side of a crankshaft. As shown in Figure 2, a girl mechanic character was added to the signs to encourage mothers and girls, who may be less interested in cars, to read the signage. Because images working with text improve understanding of signage (Serrell, 1996), images from *Cars and how they go* by Gail Gibbons (1986) and the internet site, *www.howstuffworks.com*, are also used on the signs.

Interaction signs for two car parts

Interaction signs were developed to support parent's interaction with children by scaffolding appropriate use of the exhibit and signage. First, following Bitgood's (1996) suggestion that simple phrases that challenge visitors to engage in tasks with an exhibit help visitors to engage, interaction signage pointed out which features or evidence of hands-on operation need to be encoded to make meaning of the exhibit as the exhibit designer intended. Second, previous studies showed that visitors are more likely to read signage when key ideas are given (Kool, 1985) and that questions as signage headers could increase visitors' signage reading rate (Hirshi & Screven, 1988). Based on this information, interaction signage asked questions which are answered on content signage in order to facilitate visitors' use of content signage. In particular, interaction signage was written in the open question form, which parents can directly use in conversation with their children (see Figure 3). Graphics are used to guide proper exhibit usage, not to provide further content information about car parts.

Figure 3: Interaction signage with content signage

By installing these two types of signage around the exhibit, three experimental conditions were created: 1) Content and interaction signage 2) Content signage, and 3) No Signage (see Figure 4).

Figure 4: Signage installation at three signage conditions

1) No signage

2) Content signage

3) Content and interaction signage

Procedure

Video cameras and wireless microphones were set up around the exhibits. Families were recruited as they approached the Garage/workshop exhibition area. Researchers explained that both parents and children would be videotaped while they engaged with the targeted exhibit and would also be given pre- and post-interviews. If families indicated interest, the researcher obtained informed written consent prior to their participation in interviews and observations. All pre- and post-interviews were conducted in a designated area on the museum floor. The parent's and child's pre-interview and the parent's post-interview were audio taped. The joint-interview and parent-child engagement were videotaped. For better recording of parent-child conversation while they engaged with the target exhibit, wireless microphones were attached to both parent and child.

Pre-interview

Once parents and children agreed to participate and filled out the written consent form, they were invited to the interview desk and given the interview prior to the activity. Pre-interviews for children lasted an average of 53 seconds and ranged from 36 seconds to 1 minute 26 seconds. Pre-interview for parents lasted an average of 2 minutes 5 seconds and ranged from 1 minute 8 seconds to 3 minutes 30 seconds.

Child

Before children participated in an activity with their parents, they were asked three questions about two car parts and what makes a car go in order to measure how familiar children were with inner car parts. First, the researcher showed the picture of two car parts and asked if the participants had seen them before and what they think the objects are. Then children were asked, *what makes a car go?* to examine whether children pointed out the inner mechanical car parts rather than the outer parts such as wheels, steering wheel, or gas.

Parent

The parent's pre-interview started with checking the family's general museum experience; then parents were asked the following four questions to measure the parent's general agenda in a museum: First, to determine a parent's overall expectation of the museum visit, the parent was asked, “When you planned to visit this museum, what kind of experience did you expect to have?” In specific, to measure whether a parent had a learning agenda for the family’s museum visit, parents were asked if they expected themselves and their children to learn in this museum. In the case of a parent’s indicating a learning agenda, he/she was asked to tell more, with the question, “As a parent, what kind of learning experience did you expect you and your children to have in the museum?” Third, to see how parents evaluated the experience at the targeted museum in terms of the museum’s assumed agenda, each parent was asked, “What kind of experience do you think this museum wants your family to have with this visit? Finally, to examine whether parents applied an agenda or goal to the target exhibits that differed from their general agenda, parents were shown a picture of the target exhibit and asked, “By seeing this picture, what do you think you and your child can experience or learn from this exhibit?”

Parent-child engagement with two car parts

After the pre-interview, parent-child dyads were asked to start their engagement with the engine and then move onto the differential. Parent-child dyads were asked to engage with the two car parts for as long as they wanted and to tell the researcher when they were done. Then both parent and child were provided the microphone set. Each parent-child dyad’s engagement was videotaped until they indicated that they had finished their activity.

Post-interview

When families came back to return the microphone set after finishing the activity, a post-interview was given to parent-child dyads. The joint-interview for measuring a family’s learning at the target exhibits lasted an average of 7 minutes, 5 seconds and ranged from 3 minutes, 30 seconds to 10 minutes, 16 seconds. After the joint-interview, parents were further asked about their prior knowledge of the two car parts and about their own thoughts on the signage usage.

This post-interview for parents lasted for an average of 3 minutes, 48 seconds and ranged from 2 minutes 52 seconds to 6 minutes 28 seconds.

Parent-child joint-interview

The joint-interview was given to parent-child dyads to measure both parents' and children's learning at the target exhibit. This parent-child joint-interview was videotaped and analyzed as a measure of the family's learning at the targeted exhibits. When parents and children were seated at the interview table, the researcher indicated to parents that the first chance to answer the questions would be given to children. Parents were asked to support or answer questions children could not answer, or to add ideas when they have a different idea to the answer. Then the researcher asked seven questions per car part. First, in order to measure how parents and children identified two car parts, three identification questions were asked: 1) What is this car part? 2) Where do you think you can find this car part in this car model? [by showing the die-cast car model (see Figure 5) which allows participants to see the inner car parts under the hood and underneath the car], and 3) Why does a car need this car part? (or what is the job of this car part?). Second, in order to measure how parents and children investigated two car parts to understand how each car part works, four questions per car part were asked by showing the picture of the target exhibit. For the engine: 1) What is this part (pistons) called? 2) What is the job of pistons in an engine? 3) What is this part (crankshaft) called? and 4) What is the job of the crankshaft in an engine? For the differential: 1) How do the two wheels spin? (either at the same speed or at different speeds), 2) Why do the two wheels spin at different speeds? 3) What are these parts (gears) called, and 4) What is the job of these gears? In cases where parents and children indicated that they did not engage with certain parts of the exhibit, they were not asked questions related to the sub-parts of each target exhibit.

Figure 5: Die-cast car model for the joint-interview

Parent post-interview

After the joint-interview, parents were interviewed to measure their prior knowledge of two car parts. Follow-up questions were asked on how the parent used signage and on the parent’s specific goal for the activity at the target exhibit.

a. Parent’s self-reported prior knowledge on the exhibit content

To avoid the priming effect on parents’ interaction with exhibits by the pre-interview, parent’s prior knowledge was measured after they engaged with the exhibit by asking six questions per each car per part. In order to measure parents’ prior knowledge, parents were asked if they knew the specific content of exhibits before they engaged in the activity.

First, to measure parent's knowledge about the engine, the following questions were asked: 1) Did you know where the engine is and what the engine does? 2) Did you know that the engine has pistons inside? 3) Did you know that pistons move up and down by explosion? 4) Did you know that the engine has a crankshaft inside? 5) Did you know that the crankshaft transforms pistons' up-and-down movement into a spinning motion? and 6) Did you know how the power from the engine goes to the wheels? Second, parent's knowledge about the differential was measured by the following questions: 1) Did you know what the differential is? 2) Did you know where the differential is in a car? 3) Did you know why a car needs a differential? 4) Did you know that two wheels spins at different speeds? 5) Did you know why two wheels spins at different speeds? and 6) Did you know that the differential has several gears in it and that the gears make the two wheels spin at different speeds?

b. Parent's reflection on the signage usage

In order to see how parents reflect on signage as an artifact that helps parent-child interaction and their meaning making around exhibits, the following questions were asked for parents in two signage conditions. First, the researcher checked whether parents used the sign for interaction with their children. When parents indicated that they used the signage, parents were asked whether signage was helpful in the interaction with their children about a car, and if so, how. Then parents were also asked whether signage was helpful for their own learning, and if so, how. In particular, parents in the content and interaction signage condition were asked which type of signage was particularly helpful for them to interact with their children and why. In case parents indicated that signage was not useful, they were asked if there was any particular reason they did not use signage.

c. Parent's interpretation of goal of activity at target exhibits

In order to see if signage functions for parents who did not indicate content-specific learning as their general agenda, to discern an emerged content-specific learning goal, the following questions were asked of parents once more: 1) What was your activity goal while engaging with these two exhibits?; 2) What kind of experience does this museum want to provide through these exhibits?

Coding and Analysis

Two major coding passes were conducted. First, to measure parents' and children's learning, the joint-interview was transcribed and scored. Second, parent-child engagements were transcribed and coded to describe, 1) How family attention was distributed to the exhibit and signage, 2) How parents and children made use of the exhibit and signage, 3) How parents and children talked about the exhibit and signage. One researcher coded the entire data set and a second researcher coded 20% of the transcripts to verify the reliability of the coded data.

Parents' and children's learning

Family learning was measured through how parents and children talked about two car parts at the joint-interview. Children's familiarity with the inner car parts was scored as the covariate to children's learning. Parent's self-reported prior knowledge was scored to distinguish parents with high knowledge from parents with low knowledge.

Children's familiarity with the inner car parts

Children's pre-interviews were scored to measure how familiar children were with the inner car parts. First, for the question asking respondents to identify the engine, 1 point was given if a child identified the exhibit picture as "part of the car"; 2 points were given if a child correctly identified the picture as the engine. For the second question asking respondents to identify the differential, 1 point was given if a child answered “the wheels or tires”; 2 points were given if a child indentified “the axle” with wheels. To the last question, “What makes a car go?” children were given 1 point if they mentioned the outer car parts such as wheels, steering wheels or the gas or oil; 2 points were given if children pointed out the inner car parts such as the engine or motor. All points that children earned from three questions were summed up to calculate the score of children’s familiarity with the inner car parts. The two raters agreed on 89% of the codes.

Parent’s self-reported prior knowledge

To measure parents’ prior knowledge about the two car parts, parents were asked six questions for each car part. Given that all parents reported that they knew about where the engine is and what it does, the question asking the location and the general function of the engine was excluded in scoring parents’ prior knowledge. In addition, parents who professed to know that two wheels can spin at different speeds answered that they also knew why two wheels need to spin at different speeds, so these two separate questions were combined. Parents were scored by how much they reported to know answers to questions posed at the post-interview, intended to measure parents’ prior knowledge. Scores for parent’s prior knowledge ranged from 0 to 10.

To examine the effect of parents’ prior knowledge on how parents make use of signage, parents were grouped as either high-knowledge or low-knowledge. In this study, given that parents who knew at least how the engine works for a car to move are defined as high-knowledge parents, parents who scored higher than 5 points at the self-reported prior knowledge (score ranged from 0 to 10) were grouped as high-knowledge and parents who scored lower than 5 points were grouped as low-knowledge.

Parents and children's talk about two car parts at the joint-interview

In order to measure parents' and children's learning at the target exhibit, how they talked about two car parts at the joint-interview was scored. First, to measure parents' and children's learning about how the engine and the differential work for a car to move, their answers to six questions asking the name, the location, and general function of each car part were scored (see Table 1). Next, to measure parents' and children's learning about how the pistons, crankshaft, two wheels, and gears inside of the differential work, either for the engine or for the differential, their discussions were scored as shown in Table 1. The two raters agreed on 88% of the codes.

Table 1: Parents' and children's learning scoring criteria

Meaning making space	Score range	Question	Answer
Engine [0,7]			
Identification	[0,3]	What it is	Engine (motor)
		Where it is	Point to the engine under the hood (*Point under the hood, but do not exactly point to the engine=>0.5 point were given)
		What it does	Makes power by burning gasoline (*If a child or a parent just indicated "makes a car go"=>0.5 point were given)
Piston	[0,2]	What it is	Piston
		How they work	Little explosions make pistons move up-and-down, which powers wheels to spin
Crankshaft	[0,2]	What it is	Crankshaft
		How it works	Either indicate that the crankshaft changes the up and down motion of pistons into a spinning motion, or explain that the spinning crankshaft makes the driveshaft spin, and this makes wheels spin

Differential [0,7]			
Identification	[0,3]	What it is	Differential
		Where it is	Center of the axle at the back (*In case a child or a parent points to the center of the front axle=>0.5 were given)
		What it does	Shares the power from the engine (*If a child or a parent indicated "makes wheels spin"=>0.5 were given)
Two wheels	[0,2]	How they move	At different speeds
		Why need them	Wheels need to spin at different speeds on a curvy road. To make smooth turns, outer wheels need to spin faster than inner wheels
Gears	[0,2]	What they are	Gears
		How they work	Gears make wheels move independently and allow a car to make a smooth turn

Parent–child engagement

Parent-child engagements were coded to explore how they made use of two objects, the exhibit, and signage. Prior to coding the parent-child engagement, parent-child dyads' talk was transcribed. Then, their actions in using the exhibit and signage were added to the transcription. This transcription was used for coding with video.

Attention

In order to code how parents and children distributed their attention during their activity, the primary coder, through watching the video, tracked where each participant's attentions stayed by second. At first, what each participant was looking at and when he or she started to look were recorded on the transcription, based upon the observation of where the participant's viewing was fixated, along with considering what he or she talked and did (see Figure 6). Given that the exhibit and signage were the primary objects that parents and children had to interact with, parents' or children's attention while they were looking at each other, moving around the exhibit without looking at the exhibit, or distracted away from the exhibit were excluded. Finally, how long each participant paid attention to either the exhibit or the signage was calculated. The percent of total engagement time directed toward the exhibit and signage was also calculated.

Figure 6: Transcription example

	Parent		Child			Parent-Child conversation
Time	What	Action	What	Action	Share	
						[18:24] Engine-ID---
18:24	Exhibit	Look at the ex	Exhibit	Hold the handle, start the crank	O	P: Okay, alright –so what's going on?
						C: What's this? (turns engine crank)
18:33	Sign	Point the sign and ask C to read	Exhibit	Start to crank hard	X	P: This is an engine
						P: , so if you look, what –can you read this? Mike? C: (B crank) What?
18:41	Sign	Point the sign and ask C to read, read with B	Sign	Look at the sign, read the sign	O	P: Can you read this, what this says?
						C: Under the car's hood the engine makes the power that will make the wheels go around by-
						P: burning
						C: bunging gasoline.
18:57	Exhibit	Point the ex, bend to see the CS window	Exhibit	Crank and look over the widnow	O	P: Okay, so this is the engine, like what we have in our car, right?
						C: yeah
						[19:00] Engine-Crankshaft--

Action

Beyond examining how each participant distributed his or her engagement time to two objects, each participant's actions were coded to explore how extensively and deeply parents and children made use of signage and the exhibit for meaning making.

a. Signage usage

To explore how parents and children made use of signage as the mediating tool for meaning making of the exhibit, parents' and children's action in using two types of signage was tracked. In order to address both what type of signage usage action was shown and how much of signage content was covered, the unit to observe signage using action was based on the signage content. Each action to use twelve sentences and six figures in the content signage, and six sentences in the interaction signage, was separately coded by using the following four coding schemes:

- No usage: Participant did not notice signage so that no particular behavior for using signage was shown. Or, participant took a quick glance at the signage, but he or she did not really pay careful attention to the sign content.
- Listen/ Look: Participant passively listened and looked at the signage while partners read aloud the signage text or talked about the signage content.
- Skim/ Read alone: Participant skimmed or read the signage alone without speaking out loud.
- Read out loud/ Talk about signage content: Participant read the signage text aloud or talked about the signage content loudly while his or her attention fixated on the signage.

After finishing coding of signage reading actions, the percentage of each signage usage action category was calculated to describe the way parents and children used the signage.

However, this coding scheme to examine signage reading actions might report the rate of "listen/look" and "skim/read alone" higher than is accurate. In this study, the signage usage action was coded by how each participant used the signage text or figure sentence by sentence. There were some difficulties in coding of "listen/look," or "skim/read alone" in determining which part of the signage text or which figure on each signage panel was either silently read or only skimmed, based on each participant's behavior. Because of this difficulty, when a participant either "listen/look" or "skim/read alone" one of six signage panels, signage usage actions for all observation units of one signage panel were coded in same. The two raters agreed on 87% of the codes.

b. Exhibit usage

In order to examine the effect of signage on parents' and children's exhibit usage, how parents and children used the exhibit was coded in two ways. First, considering that both the engine and the differential have two observable points that allow visitors to explore in order to understand how each car part works, two inquiry spaces per two car parts (e.g., Pistons and the crankshaft of the engine, two wheels and gears of the differential) were defined. Then, whether parents and children covered each inquiry space was coded. Later, the covered inquiry spaces by each parent and child were counted to examine how extensively each parent and child explored the exhibit.

Next, the specific actions at each inquiry space (e.g., glanced at pistons through window without cranking, or cranked handle and simply looked at two wheels' spin) were transcribed. Then, each action was coded in three levels:

- No engagement: Participants skipped manipulating or looking through the window to check the subpart of the engine or the differential in an inquiry space.
- Lower level of exhibit usage: Participant noticed and took a glance at the subparts or looked through the window and saw the subparts. Or participants simply checked what happened after operating the exhibit without further investigation.
- Higher level of exhibit usage: Participants investigated the exhibit parts more than one way to observe the feature and evidence as the exhibit designer intended beyond cranking the handle and looking through the window (e.g., Participants looked into both windows to check how pistons' movements related to the crankshaft at the engine. At the differential, participants experimented with wheels' speed or direction).

After coding each parent's and child's exhibit usage action in three levels, the level of exhibit usage at each inquiry space was scored: No engagement was given 0 points, lower level of exhibit usage was given 1 point, and higher level of exhibit usage was given 2 points. Then, all scores given at each inquiry space were summed as a measure to examine how deeply parents and children investigated the exhibit. The two raters agreed on 90% of the codes.

Talk

Parent-child talk was coded in two ways: First, as a simple measure to look into how close parents' and children's conversation about the exhibit was to the meaning that exhibit designers intended to deliver, the overall content of parent-child dyads' conversation was coded. Second, talks about the signage and exhibit were separately analyzed.

a. Learning Talk

This study targeted the engine and the differential, allowing families to manipulate by probing how the mechanical components of each car part (e.g., pistons, crankshaft) are jointed to make each car part work and to make a car move. The parent-child dyad's learning talk was measured by how deeply parents and children talked about the two car parts in order to identify them and to investigate how the mechanical components of the two car parts work.

Given that parent-child dyads need to take three steps for an understanding of how the two car parts work and how they work for a car to move, the parent-child conversation was broken down into three units for each car part: First, at the exhibit identifying space, how the parent and child talked to identify each car part in terms of how each part works to mobilize a car was scored. As shown in Table 2, the parent-child conversation was scored by whether they named the car parts, whether they talked about the location of the two car parts, and whether they discussed the function of the two car parts. Second, at two inquiry spaces, how the parent and child talked about two mechanical sub-components of each car part to understand how each exhibit component works for either the engine or the differential was scored (see Table 2). To calculate learning talk score, all the points that each parent-child dyad gained were added up. Scores ranged from 0 to 12. The two raters agreed on 93% of the codes.

Table 2: Learning talk scoring criteria

Car part	Meaning making space	Score range	Score criteria to earn a point
Engine	Identification space	[0,3]	• Identify the engine • Discuss the location of the engine • Discuss how the engine makes a car go by burning gasoline
	Two inquiry spaces		
	Pistons	[0,3]	• Describe pistons' up-and-down movement • Identify pistons • Discuss how the pistons work for the engine
	Crankshaft	[0,3]	• Describe crankshaft's spinning movement • Identify the crankshaft • Discuss how the crankshaft works for the engine
Differential	Identification space	[0,3]	• Identify the differential • Discuss the location of the differential • Discuss how the differential makes two wheels share the power from the engine
	Two inquiry spaces		
	Two wheels	[0,3]	• Talk about the two wheels' different movement by cranking differently (e.g., cranking direction) • Describe the different speed of two wheels • Discuss why two wheels need to spin at different speeds
	Gears	[0,3]	• Describe how five gears are spinning • Identify them as gears

a. Signage talk

In order to explore how signage text and figures were used in parent-child conversations, first the amount of signage talk was counted. The primary coder counted the amount of utterance made while parents' and children's attention was fixed on signage, using transcription that recorded the attention span either to the exhibit or to signage along with the parent-child dyads' conversation (see Figure 6). In addition, talks that occurred while participants were watching their partner or moving were included as the signage talk if the participant talked about signage content. In case of talk that occurred while the participant's attention was in transit, either to or from the exhibit, content of talk was coded either as signage talk or as exhibit talk.

Total signage talk was recounted by considering the type of signage. First, considering the type of signage, signage talk occurring while participants used the content signage was counted in the two signage conditions. Then, interaction signage talk was separately counted in the content and interaction signage condition. Next, given that not all talk while using signage pertained to signage *content*, and that talk occurred regarding *use* of signage, signage content talk and signage usage talk were separately counted: All signage talk for making meaning of signage text and figures was coded as signage content talk. All the signage talk that did not reflect the signage content was coded as signage usage talk. For example, parents often asked children to read together or watch the signage while they read signage aloud (e.g., Oh, look at this.). Also, there were talks to negotiate parent and child roles for use of signage (e.g., You wanna read that? Yeah?). There were talks to express their affection, etc. These talks, which were not related to the signage content, were categorized as signage usage talk.

b. Exhibit talk

In order to examine the effect of signage on parents' and children's talks about the exhibit, the amount and the kinds of parents' and children's talk about the exhibit were analyzed. First, all the utterance made while parents' and children's attention stayed on the exhibit was counted using transcription. Second, to look into specific kinds of talk while parents and children used the exhibit, the following coding scheme was developed, building on an existing coding scheme used for coding learning conversation in museums (Allen, 2002). The conversation codes developed for this study are listed below with their definitions. The two raters agreed on 86% of the codes.

- Identification: Any kinds of talk that stated or inferred the names of an exhibit or a part of the exhibit (e.g., "Oh, that's piston.")
- Description: Any kinds of talk that described the static aspect of the exhibit as features and the interactive aspect of the exhibit as evidence (e.g., [Looking at the gears inside of the differential] "One big one, one little one, one little one. . .", or "That one looks like it's going faster than that.")
- Simple inference: Any kinds of talk to make a inference without linking to exhibit feature or to the evidence that exhibit generates (e.g., "Oh, this shows how a car works", or "This is about how the engine works")
- Complex Inference: Any kind of talk to make a concrete inference by connecting with exhibit elements or feature or to the evidence that the exhibit generates (e.g., "You see the teeth, how they get together, so you can change the movement from here, from this direction to this direction.")
- Connection: Any kinds of talk to make explicit connections with prior knowledge or experience about a car. (e.g., "There is another thing before this where the gas goes into chambers." "This is showing you a car where only the back wheels move, but in our van, only the front wheels move.")

- Hands-on usage: Any kinds of talk for negotiating roles to make use of the exhibit for discussion of how to use the exhibit (e.g., "I'll make it spin and you look.")
- Others: Any kinds of talk that did not frequently occur in parent-child conversation such as meta-cognition (e.g., "I didn't know about that."), prediction (e.g., "Here I will turn it for you, you can see the gears moving."), and meta-performance (e.g., "We are supposed to stay over here."), talk that simply restated what a partner said , and talk that expressed simple agreement to partner's talk or emotion (e.g., "Isn't it simple, huh?" "Cool") were collapsed under "other."

CHAPTER 4

RESULTS

The results are organized in light of the two main groups of research questions in this dissertation: 1) How does signage about content and interaction affect parents' and children's learning, and what is the role of parent prior knowledge? 2) How does signage about content and interaction affect parent-child engagements, and what is the role of parent prior knowledge?

Parents' and Children's Learning

In order to examine whether there was a difference in parents' and children's learning across the three signage conditions, children's and parents' learning was measured through parent-child joint-interviews after their engagement with the target exhibit.

Parents' learning

To examine whether there was interaction between the three signage conditions and parents' prior knowledge, a 3 (Signage condition) x 2 (Parent knowledge) ANOVA was performed with parents' joint-interview score as the dependent variable. This analysis revealed that the effect of the signage condition interacted with the parent prior knowledge factor, F (2, 39) = 8.96, p <.00. In fact, the average score of high knowledge parents' self-reported prior knowledge (M=9.0 from 0 to 10 score range, SD=1.6) indicated that most parents with high knowledge engaged in the activity already having ideas about how the two car parts work. Therefore, no difference was shown in high knowledge parents' learning scores at the joint-interview across the three signage conditions (see Table 3). On the other hand, a significant difference in parents' learning by signage conditions was found in the low knowledge parent group. Parents with low knowledge in the content and interaction signage (M=10.9, SD=2.0) and content signage (M=8.9, SD=3.1) conditions were more likely to learn about the two car parts than were parents with low knowledge in the no signage condition (M=3.6, SD=2.0).

Table 3: Parents' and children's learning

		Content and interaction		**Content**		**No signage**	
		M	SD	M	SD	M	SD
Parent	LK (N=8)	10.9	2.0	8.9	3.1	3.6	2.0
	HK (N=7)	11.7	1.5	11.1	1.8	11.0	2.6
	Total	11.3	1.8	9.9	2.7	7.1	4.4
Child	LK (N=8)	5.9 [2]	2.6	5.6	2.6	2.6	1.8
	HK (N=7)	5.9	1.4	4.7	2.9	4.9	2.3
	Total	5.9	2.1	5.1	2.7	3.7	2.3

Children's learning

How did signage affect children's learning in the three conditions? Considering that the effect of signage on parent's learning was different according to a parent's prior knowledge, the effect of parent knowledge on children's learning was also examined. A 3 (Signage condition) x 2 (Parent knowledge) ANCOVA was performed with children's joint-interview score as the dependent variable and children's familiarity with the inner car parts as a covariate. This analysis showed that there was only a main effect for signage condition, $F(2, 38) = 3.58$, $p < .05$. Post-hoc tests revealed that there was a significant difference between the content and interaction condition and the no signage condition, $p < .05$. This indicated that children in the condition where both content and interaction help were provided (M=5.9, SD=2.1) learned more about two car parts than did children in the no signage condition (M=3.7 SD=2.3). However, children's familiarity with the inner car parts was a significant covariate with the effect of signage, F (1, 38) = 6.34, p< .05. That is, children who were more familiar with the inner car parts in the signage condition were more likely to learn from the activity at the target exhibit than were other children. Although parent knowledge did not affect children's learning across the three conditions, there was significant difference in children's learning based on parent knowledge in the no signage condition, t (13) = 2.2, p <.05. In the no signage condition, children with high knowledge parents were more likely to learn about a car than were children with low knowledge parents.

Parent-Child Engagement: Usage of Two Objects

Given that the goal of this study is to explore the mediating role of signage for museum visitors, the analysis of parent-child engagement focused on how two objects, the exhibit and signage, were used in parent-child engagement across the three conditions. How parents and children made use of the two objects was addressed in three ways: 1) How attention was distributed to two objects throughout family engagement in three conditions, 2) How parents and children made use of two objects in the three conditions, and 3) How parents and children talked about the two objects in the three conditions. Along with differences in signage condition, the effects of parents' prior knowledge were also examined.

Attention

Engagement time

Prior to exploring how parent and child attention was distributed across the exhibit and signage, I first examined whether there were differences in total engagement time at the target exhibit across the three signage conditions. A 3 (Signage condition) x 2 (Parent knowledge) ANOVA was performed with total engagement time as the dependent variable. This analysis showed a main effect for signage condition, $F(2, 39) = 5.56$, $p < .01$. Post-hoc tests showed significant differences between the two signage conditions and the no signage condition (no signage vs. content, $p = .04$; no signage vs. content and interaction, $p = .01$). Parent-child dyads in the two signage conditions (content and interaction: 4min 26sec, SD=1min 6sec; content: M=4min 9sec, SD=1min 44sec) spent significantly more time at the target exhibit than did those in the no sign condition (M=2min 45sec, SD=1min 21sec).

Attention spans to the exhibit and signage

Attention to either the exhibit or to the signage was also separately tracked to determine where the differences in total engagement time came from.

First, how long did attention stay on signage? 2 (Signage condition) x 2 (Parent knowledge) ANOVAs were performed with parents' and children's attention to signage as the dependent variables. This analysis showed no difference in how long parents paid attention to the signage in the two signage conditions (content and interaction: M=1min 35sec, SD=59sec; content: M=1min 40sec, SD=59sec). Parents in the content and interaction signage condition spent 36% and parents in the content signage condition spent 40% of their total engagement time on the signage. However, parent knowledge did affect their attention time to signage, $F(1, 26) = 4.22$, $p < .05$. Parents with high knowledge (M=1min 15sec, SD=58sec) spent less time on signage than did parents with low knowledge (M=1min 57sec, SD=52sec).

As shown in Table 4, children spent less time on signage than did parents. Children in the content and interaction signage condition spent 30% and children in the content signage condition spent 31% of their engagement time on signage. No difference in children's attention to the signage was shown either by signage condition or by parent knowledge (see Table 4).

Table 4: Attention span to signage and the exhibit

		Content and interaction		Content		No signage	
		M (SD)	%	M (SD)	%	M (SD)	%
Parents							
Signage	LK (N=8)	2min 2sec (53sec)	48%	1min 53sec (54sec)	45%	5sec (5sec)	3%
	HK (N=7)	1min 4sec (53sec)	23%	1min 25sec (1min 5sec)	34%	0sec (0sec)	0%
	Total	1min 35sec (59sec)	36%	1min 40sec (59sec)	40%	2sec (4sec)	1%
Exhibit	LK (N=8)	1m 33sec (30sec)	39%	1min 41sec (1min 3sec)	40%	2min 4sec (1min 3sec)	79%
	HK (N=7)	2min 46sec (1min 26sec)	59%	2min (1min 32sec)	49%	2min 5sec (58sec)	71%
	Total	2min 7sec (1min 11sec)	48%	1min 50sec (1min 16sec)	44%	2min 5sec (58sec)	76%
Children							
Signage	LK (N=8)	1min 35sec (52sec)	38%	1min 28sec (50sec)	35%	1sec (2sec)	1%
	HK (N=7)	54sec (49sec)	19%	1min 15sec (1min 14sec)	30%	0sec (0sec)	0%
	Total	1min 16sec (53sec)	29%	1min 22sec (1min)	33%	0sec (1sec)	0%
Exhibit	LK (N=8)	2min 11sec (46sec)	52%	2min 8sec (1min 4sec)	51%	2min 14sec (1min 2sec)	86%
	HK (N=7)	2min 58sec (1min 6sec)	63%	2min 18sec (1min 17sec)	56%	2min 10sec (1min 5sec)	74%
	Total	2min 33sec (59sec)	58%	2min 13sec (1min 8sec)	53%	2min 12sec (1min 1sec)	80%

Next, in order to examine whether there were differences in parents and children's attention span to the exhibit itself, 3 (Signage condition) x 2 (Parent knowledge) ANOVAs were performed with parents' and children's attention to the exhibit as the dependent variables. No differences either based on signage condition or on parent knowledge were found in how long parents' attention stayed on two car parts (see Table 4). This indicates that the difference in the total engagement time was mostly due to the difference in signage viewing time, not to the time that parents and children spent on the exhibit.

As shown in Table 4, children spent slightly more time interacting with the exhibit than did parents. Children in the no signage condition spent 80% of their total engagement time while children in the content and interaction condition spent 58%, and children in the content condition spent 53% of their engagement time on the exhibit. However, no difference was found in children's attention time to the exhibit (see Table 4). Parent knowledge also did not affect children's attention time to the exhibit.

Action

In order to explore how parents and children make use of the exhibit and signage throughout their engagement, their actions with the two objects were coded separately.

Signage usage

Content signage

In order to examine whether there were differences in how parents used the content signage, 2 (Signage conditions) x 2 (Parent knowledge) ANOVAs were performed with the ratios of each signage usage action category as the dependent variables. These analyses revealed no significant condition differences in parents' use of content text (see Table 5). On average, parents read aloud 43% of content signage text and skipped about half (47%). However, there was a main effect for parent's prior knowledge on how often parents skipped content signage text, F (1, 26)= 4.52, $p < .05$. Parents with high knowledge (M=.57, SD=.21) were more likely to skip text than were parents with low knowledge (M=.38, SD=.26). However, no significant effects were found on the other signage usage action categories due to parent prior knowledge.

Table 5: Signage usage action

	Parents							Children						
	Content text			Content figure			Inter-action	Content text			Content figure			Inter-action
	Content and interaction	Content	Total	Content and interaction	Content	Total	Content and interaction	Content and interaction	Content	Total	Content and interaction	Content	Total	Content and interaction
No usage	.46	.48	.47	.66	.54	.60	.60	.57	.54	.56	.69	.66	.67	.72
Listen/ Look	.03	.06	.04	.00	.06	.03	.03	.25	.26	.26	.21	.31	.26	.17
Skim/ Read alone	.09	.03	.06	.03	.03	.03	.05	.01	.02	.01	.00	.02	.01	.01
Read out loud/ Talk about signage	.43	.43	.43	.31	.37	.34	.31	.16	.18	.17	.06	.01	.03	.09

Next, how were the figures in the content signage used? To examine whether there were differences in using figures, 2 (Signage conditions) x 2 (Parent knowledge) ANOVAs were performed with the ratios of each signage-reading action category as dependent variables. No differences in using content signage figures were found between conditions. Neither did parent knowledge make a difference in using content signage figures between two parent knowledge groups. On average, 34% of the content signage figures were mentioned in parent-child conversation.

In the case of children, no significant differences were found in children's signage reading actions between the two signage conditions. Again, there was a main effect of parent's prior knowledge on how often children skipped text, F (1, 26) = 4.21, p< .05. That is, children with high knowledge parents (M=.68, SD=.45) were more likely to skip content text than were children with low knowledge parents (M=.45, SD=.33). Parent knowledge did not affect children's other signage usage actions. Overall, children did not use 56% of the content signage text and 67% of the figures.

Interaction signage

How was the interaction signage used in the content and interaction signage condition? In order to examine whether there were differences in using the two types of signage, t-tests were performed. Although parents in the content and interaction signage condition seemed less likely to read interaction signage aloud (31%) than content signage (43%), and more likely to skip interaction signage (60%) than content signage (46%), no significant difference was found. Next, to examine whether there were differences in using interaction signage by parent knowledge, t-tests were performed. While parents with high knowledge were more likely to skip using the content signage than were parents with low knowledge, no difference in using interaction signage text was found.

In the case of children, 72% of the interaction signage text was skipped and only 9% read out loud. Just as the listen/look was the second most frequent signage usage action category in children's content signage usage, children often looked at interaction signage and listened while parents read the text aloud to them (17%).

Exhibit usage

Given that the engine and the differential exhibits have two observable points that allow visitors to explore each car part, two inquiry spaces per car part were defined. The exhibit usage was examined in two ways: 1) How extensively did parents and children cover inquiry spaces at the exhibits? and 2) How deeply did parents and children investigate exhibits?

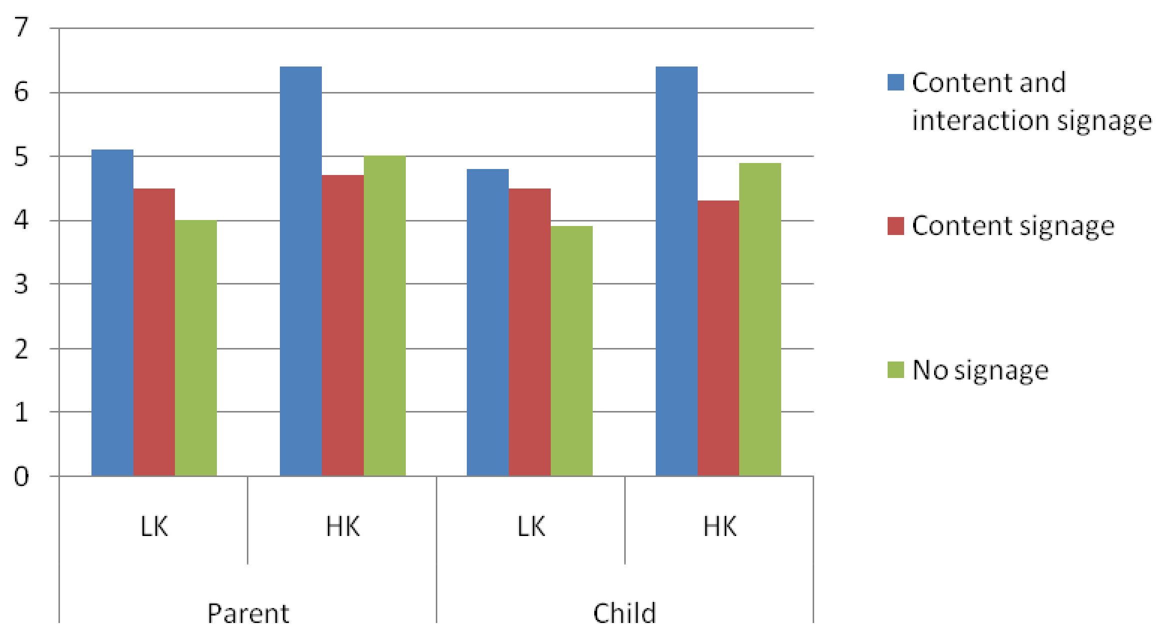
Inquiry space

In order to examine how extensively parents and children explored the four possible inquiry spaces, 3 (Signage condition) x 2 (Parent knowledge) ANOVAs were performed with the number of covered inquiry spaces by parents or children as the dependent variables. This analysis showed no significant differences in the number of covered activity spaces by either parents or children across the three signage conditions. There was only a main effect of parent knowledge on the number of covered activity spaces by children, F (1, 39) =5.35, p <.05. Children with high knowledge parents (M=3.6, S=.68) were more likely to cover more activity spaces than were children with low knowledge parents (M=3.0, S=.81).

Exploration of exhibits

In order to examine how deeply parents and children explored the exhibit beyond seeing whether they engaged or not, 3 (Signage condition) x 2 (Parent knowledge) ANOVAs were performed with the sum of exhibit usage scores at the four inquiry spaces as the dependant variables. The analyses revealed a significant difference in how parents operated and observed the exhibit across the three signage conditions, F (2, 39) =3.65, p <.05.

Figure 7: Exploration of the exhibit



As shown in Figure 7, parents in the content and interaction condition (M=5.7, SD=1.3) were more likely to investigate the exhibit parts as the exhibit designer intended than were parents in the content only condition (M=4.6, SD=1.3) and the no signage condition (M=4.5, SD=1.7). There was a marginal effect of parent knowledge, F (1, 39) =3.85, p=.057; that is, parents with high knowledge (M=5.4, SD=1.5) were somewhat more likely to examine the exhibit as the exhibit designers intended than were parents with low knowledge (M=4.5, SD=1.5).

In the case of children, there was only a main effect of signage condition, F (2, 39) =3.45, p <.05. Signage condition affected how children operated the exhibit and observed evidence, but parent knowledge had no effect. Children in the content and interaction signage condition (M=5.5, SD=1.5) were more likely to experiment with the exhibit to understand what it does and what it means than were children in the content condition (M=4.4, SD=1.5) and the no signage conditions (M=4.3, SD=1.6).

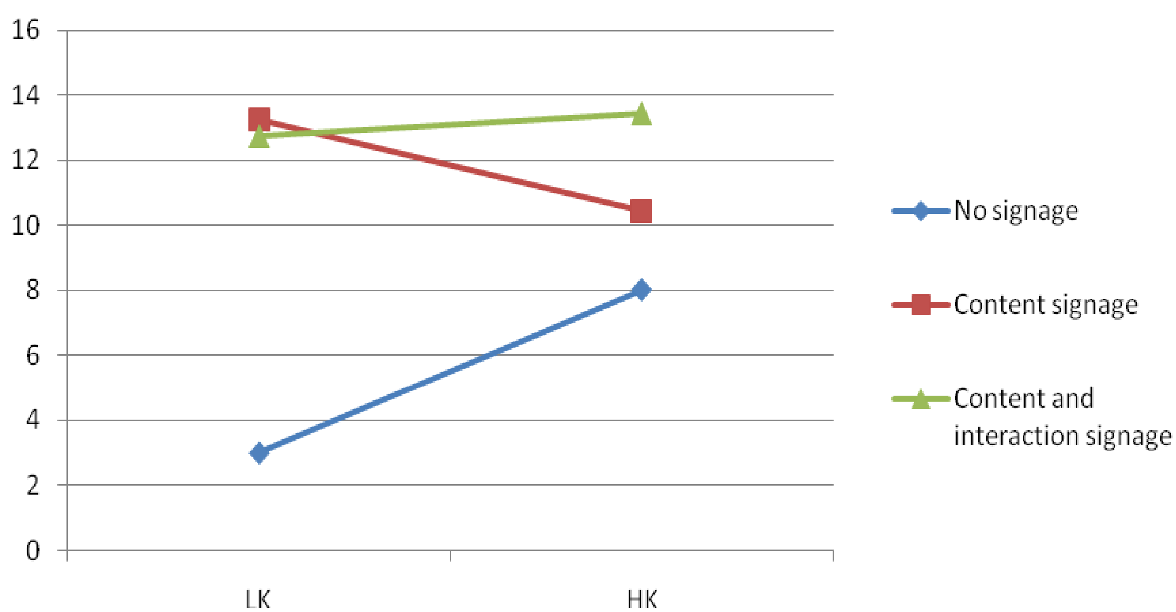
Talk

In order to explore how parents and children talked about signage and the exhibit, first, the overall content of talk relating to the two car parts was examined. Then the amount and the kinds of talk about signage and the exhibit were separately looked into.

Learning Talk

In order to examine whether parents and children made meaning of two car parts as the exhibit designers intended in their conversation, a 3 (Signage condition) x 2 (Parent knowledge) ANOVA was performed with the learning talk score as the dependent variable. This analysis showed that there was interaction between signage condition and parent knowledge. As shown in Figure 8, parent-child dyads in the content and interaction condition (M=13.1, SD=2.6) and the content condition (M=11.9, SD=4.0) were more likely to show learning talk than were parent-child dyads in the no signage condition (M=5.3, SD=3.8), F (2, 39) =24.8, p< .00. However, the signage did not affect high knowledge parent-child dyads in the content condition as much as it did low knowledge parent-child dyads and parent-child dyads in the content and interaction condition, F (2, 39)= 5.75, p< .01. Therefore, high knowledge parent-child dyads (M=10.4, SD=4.0) showed slightly lower learning talk scores than did low knowledge parent-child dyads in the content condition (M=13.0, SD=3.8), while high knowledge parent-child dyads usually showed higher learning talk scores than did low knowledge parent-child dyads in the two other conditions (see Figure 8).

Figure 8: The interaction between signage condition and parent knowledge



Signage talk

In order to explore how parents and children used signage in their conversation, parents' and children's talk while their attention was fixated on the signage was counted.

First, in order to examine whether there was a difference in the amount of signage talk by the signage condition and parent's prior knowledge, 2 (Signage conditions) x 2 (Parent knowledge) ANOVAs were performed with the frequency of talk about signage as the dependent variable. These analyses showed that there was only a main effect for parent's prior knowledge on how often parents talked about signage, F (1, 26) =6.48, $p< .05$. That is, regardless of the amount of information given, parents in the two signage conditions showed a similar amount of talk about signage. However, parent's prior knowledge affected how often parents talked about signage. High knowledge parents (M=9.8, SD=6.7) were less likely to talk about the signage than were low knowledge parents (M=17.8, SD=9.8). How much children talked about signage were not affected either by signage condition or by parent's prior knowledge (see Table 6).

Table 6: Signage talk

	Content and interaction						**Content**					
	Low knowledge		High knowledge		Total		Low knowledge		High knowledge		Total	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Parent	19.5	10.0	8.3	2.9	14.3	9.5	16.0	9.7	11.3	8.8	13.8	9.2
Content vs. Usage												
Content	17.1	9.0	7.4	3.0	12.6	8.3	12.9	8.5	9.9	6.7	11.5	7.6
Usage	2.4	1.9	0.9	1.5	1.7	1.8	3.1	1.6	1.4	2.3	2.3	2.1
By signage content												
Content	13.3	7.3	6.0	2.1	9.9	6.5	16.0	9.7	11.3	8.8	13.8	9.2
Interaction	6.3	3.8	2.3	2.4	4.4	3.8						
Child	5.7	3.2	2.9	3.5	4.3	3.5	6.3	5.3	3.6	3.5	5.0	4.6
Content vs. Usage												
Content	3.6	2.4	2.3	3.5	3.0	3	4.8	4.7	2.0	2.4	3.5	3.9
Usage	2.0	2.0	0.6	0.8	1.3	1.7	1.5	1.9	1.6	1.1	1.5	1.6
By signage content												
Content	4.3	3.5	2.0	1.9	3.2	3.0	6.3	5.3	3.6	3.5	5.0	4.6
Interaction	1.4	0.9	0.9	1.6	1.1	1.2						

Next, given that signage talk consists of signage content talk and signage usage talk, 2 (Signage conditions) x 2 (Parent knowledge) ANOVAs were performed to examine separately if there were differences in the amount of signage content talk or signage usage talk by signage condition or parent knowledge. These analyses showed no difference in the amount of either type of talk by signage condition. However, parent prior knowledge affected not only the signage content talk, F (1, 26) =5.64, $p < .05$, but also the signage usage talk, F (1, 26) =5.74, $p < .05$. Parents with high knowledge were less likely to talk than were parents with low knowledge (see Table 6). Neither the amount of children's signage content talk nor that of signage usage talk was affected by signage condition or parent knowledge.

In addition, given that content signage is given to both signage conditions, 2 (Signage conditions) x 2 (Parent knowledge) ANOVAs were performed to examine if there were differences in the amount of signage talk about the content signage by condition and by parent's prior knowledge. There was no significant difference in the amount of talk about content signage between the two signage conditions. That is, adding interaction signage did not significantly affect the amount of parent's talk about content signage in the content and interaction condition. However, parent's prior knowledge affected how often parents talked about the content signage, F (1, 26) =4.63, $p < .05$. Parents with high knowledge (M=8.6, SD=6.7) were less likely to talk about the content signage than were parents with low knowledge (M=14.6, SD=8.4). How much children talked about the content signage was not affected either by signage condition or by parent knowledge.

Exhibit talk

To examine whether there were differences in the amount of talk about the exhibit across the three conditions, talk occurring while parents' and children's attention focused on the exhibit was counted. 3 (Signage condition) x 2 (Parent knowledge) ANOVAs were performed with the amount of talk about the exhibit as the dependent variable. No significant difference was found for signage condition or parent prior knowledge (see Table 7).

Table 7: Amount of exhibit talk

		Content and interaction		**Content**		**No signage**	
		M	SD	M	SD	M	SD
Parent	LK	21.6	9.8	19.5	7.2	25.8	14.0
	HK	33.0	13.9	26.9	13.1	27.7	19.2
	Total	26.9	12.8	22.9	10.7	26.7	16.0
Child	LK	12.6	6.2	9.6	4.3	11.3	4.7
	HK	16.3	8.4	11.4	5.5	8.4	4.8
	Total	14.3	7.3	10.5	4.8	9.9	4.8

Next, in order to examine if there were differences in how they talk about the two car parts, specific types of talk were coded. 3 (Signage condition) x 2 (Parent knowledge) ANOVAs were performed with the amount of talk in each talk category as the dependent variables. First, there were main effects for signage condition on two categories of parents' talk: description of features and evidence and complex inference. Parents in the content and interaction signage condition were more likely to describe the features or evidence of the exhibit than were parents in the other conditions, F (2, 39) =3.32, p< .05. In addition, parents in the content and interaction condition were more likely to use complex inference while talking about the two car parts, F (2, 39) =5.96, p< .01 (see Table 8).

Table 8: Type of parent's exhibit talk

Parent's talk		Content and interaction		Content		No signage	
		M	SD	M	SD	M	SD
Identification	LK	0.8	0.7	1.5	1.2	0.3	2.0
	HK	3.6	1.9	3.1	2.8	3.1	3.1
	Total	2.1	2.0	2.3	2.2	3.0	2.4
Description	LK	3.5	2.1	1.9	2.1	2.3	2.3
	HK	5.4	4.3	2.6	3.2	2.4	1.4
	Total	4.4	3.3	2.2	2.6	2.3	1.9
Simple inference	LK	0.8	1.3	1.0	2.1	0.5	0.8
	HK	1.0	1.2	1.3	1.1	1.3	1.1
	Total	0.9	0.9	1.1	1.6	0.9	1.0
Complex inference	LK	2.9	1.9	1.1	2.4	0.6	0.7
	HK	5.0	3.6	2.1	2.7	1.9	1.8
	Total	3.9	2.9	1.6	2.5	1.2	1.4
Connection	LK	0.0	0.0	1.0	1.6	1.6	1.8
	HK	2.9	2.9	1.9	1.8	3.9	3.3
	Total	1.3	2.4	1.4	1.6	2.7	2.7
Hands-on	LK	5.9	3.8	5.4	2.6	5.9	3.4
	HK	5.6	2.4	5.6	2.5	4.9	3.5
	Total	5.7	3.1	5.5	2.4	5.4	3.4

Second, there were main effects of parent prior knowledge on three categories of parent's talk: identification, complex inference, and connection. Parents with high knowledge were more likely to identify the two car parts or components of those parts than were parents with low knowledge, F (1, 39) =6.56, p< .05. Parents with high knowledge were also more likely to make inferences about the exhibit in more concrete ways than were parents with low knowledge, F (1, 39) =4.48, p< .05. Parents with high knowledge again were more likely to talk about two car parts by making connections with their prior knowledge or their prior experience than were parents with low knowledge, *F* (1, 39) =10.07, *p*< .01 (see Table 10b).

In contrast to differences in parents' talk based on category, no significant differences were found in children's talk based on category (see Table 9).

Table 9: Type of children's exhibit talk

Children's talk	**Content and interaction**		**Content**		**No signage**	
	M	SD	M	SD	M	SD
Identification	0.7	0.8	0.9	1.2	0.9	1.8
Description	2.5	2.2	1.4	1.4	1.8	1.8
Simple inference	0.6	1.2	0.3	0.6	0.5	0.6
Complex Inference	0.6	0.8	0.1	0.4	0.4	0.6
Connection	0.5	0.7	0.1	0.3	0.2	1.0
Hands-on	1.0	1.1	0.8	0.9	0.4	0.6

Summary of main findings

In answer to two research questions, this study showed that parents and children learned and engaged differently across the three levels of signage as shown in Table 10. The first research question focused on examining the effect of two types of signage and parent prior knowledge on parents and children's learning. This study showed that signage particularly helped parents with low knowledge learn about the exhibit content of how the two car parts work. Along with parents, children in the two signage conditions were better at talking about the two car parts in terms of how they work than were children in the no signage condition.

Table 10: Summary of main findings

	By signage condition	By parent knowledge
RQ 1. FAMILY LEARNING		
Parents learning	Interaction between signage condition and parent knowledge. While no differences in high knowledge parents' learning were found, signage affected low knowledge parents' learning.	
Children learning	Children in two signage conditions were more likely to learn about two car parts. Significant difference in children's learning particularly shown between content and interaction signage condition and the no signage condition.	No difference in children's learning made by parents' knowledge. Only in the no signage condition, parent knowledge affected children's learning.
RQ 2. PARENT-CHILD ENGAGEMENT		
Attention		
Engagement time	Parent-child dyads in two signage conditions spent longer time with the exhibit.	No significant difference
Attention span to signage	Difference in the engagement time across signage conditions was explained by the attention span to signage.	Parents with high knowledge spent less time with signage than parents with low knowledge.
Attention span to the exhibit	No difference was found in the attention span to the exhibit.	No significant difference
Action		
Signage usage	No difference in actions to use content signage between two signage conditions. * In content and interaction signage condition: No differences in using two types of signage were found.	Parents with high knowledge were more likely to skip use of content signage text. No difference was found in using content signage figure. * In the content and interaction signage condition: No difference in using interaction signage by parent knowledge

<u>Exhibit usage</u>		
Inquiry space	No difference was found in the covered inquiry space among three signage conditions	No significant difference
Exploration of exhibit	Parents in content and interaction signage conditions were more likely to examine the exhibit as the exhibit designers intended.	Marginal effect: Parents with high knowledge were slightly more likely to use the exhibit as the exhibit designers intended than were parents with low knowledge.
Talk		
<u>Learning talk</u>	Interaction between signage condition and parent knowledge. Signage overall supported parent-child dyad's learning talks about two car parts. But it did not affect parents with high knowledge in content only signage condition as much as it affected other parents in the two signage conditions.	
<u>Signage talk</u>		
Amount of signage talk	Similar amount of signage talk between two signage conditions.	Parents with high knowledge were less likely to talk about signage than were parents with low knowledge.
Types of signage talk	*No difference in signage usage or signage content talk between two conditions. *No difference in the content signage talk between two conditions.	*Parents with high knowledge were less likely to talk to use signage or to talk about the signage content.
<u>Exhibit talk</u>		
Amount of exhibit talk	Similar amount of exhibit talk across three signage conditions.	No significant difference
Types of exhibit talk	Parents in the content and interaction signage condition were more likely to describe the features or evidence and to use complex inference while they talk about the exhibit.	Parents with high knowledge were more likely to talk to identify two car parts, to make more complex inferences about the exhibit, and to talk about the exhibit by making connection with their prior knowledge or experience.

The second research question focused on examining the effect of two types of signage and parent prior knowledge on parent-child engagement. This study showed differences among the two signage conditions and the no signage condition in how long parent-child dyads engaged with the exhibit and in how they addressed the educational messages that the exhibit designers intended to deliver. As parents made use of signage in the two signage conditions, their total engagement times with the exhibits increased correspondingly. By using information on signage, parents in the two signage conditions were better at addressing the educational messages in their conversations with children than were parents in the no signage condition.

However, adding interaction signage to content signage made no difference in the way families used and talked about signage. No differences were found in attention span to signage, action of using signage, or the amount and type of signage talk. Instead, interaction signage impacted how deeply parent-child dyads explored the exhibit and how parents talked about the exhibit in the content and interaction condition. Parent-child dyads in the content and interaction condition were more likely to explore the exhibit appropriately for an understanding of how cars work. Parents in this condition were more likely to describe features and evidence and more likely to make complex inferences about how two car parts work.

In addition to signage condition, parent prior knowledge also had effects. Parents with high knowledge were more likely to skip content signage text than were parents with low knowledge; thus, parents with high knowledge spent less time using signage. Children with high knowledge parents were slightly better at exploring the exhibit for meaning making. They also talked more about the exhibit to identify the exhibit, make complex inferences, and connect with their prior knowledge or experience.

Parent-child Engagement Examples

In order to understand how signage as an external tool is used in family engagement in a museum, this study examined how adding signage affected participants' attention, action, and talk. The quantitative analyses showed that the presence of signage and parents' prior knowledge affect the way to engage with exhibits and to make meaning of them. In particular, the presence of signage for scaffolding interaction affected not only signage related behavior and talk, but also parents' actions in using the exhibit and their kinds of talk about the exhibit. Nevertheless, the quantitative findings were limited in describing sufficiently how parent- child dyads explored the two exhibits. Therefore, in this section, parent-child engagement examples were selected to address how parent-child dyads' engagement looked different in the three signage conditions and by parents' prior knowledge.

Parent-child engagement in the no signage condition

In order to understand how signage is used as an external tool for a museum activity, it was necessary to look into what kinds of difficulties parents had in conditions where no information about the exhibit was provided. Therefore, prior to looking into how signage affected parent-child engagement in the two signage conditions, two parent-child engagements in the no signage condition were selected as examples to describe how parents and children made meaning of two car parts without any information about them. Given that parent prior knowledge affected what children learned and how parents talked about the exhibit in the no signage condition, low knowledge parent-child engagement will be compared with high knowledge parent-child engagement.

Low knowledge parent-child engagement in the no signage condition

In the no signage condition, parent-child dyads were only informed that the target exhibit is part of a car so that low knowledge parent-child engagements often started with an attempt to identify which car parts the target exhibit presents. However, parents with low knowledge in the no signage condition often failed to identify the car part, and their engagements often ended up only as explorations of what the exhibit does. Consider the following mother and an 8-year-old boy as they showed difficulties in identifying the two car parts and in finding what to say about them:

[Engine]

(Both mother and son looked at the engine.)

Mom: See what it is.
Son: I have no idea.
Mom: These are car parts. This is a part of a car.

(Mom cranked the handle and looked inside of the crankshaft window. Son also looked inside of the crankshaft window)

Mom: What part of the car do you think this is?
Son: I don't know.

(Mom and son switched roles. Son started to crank)

Mom: Here, come use that, come see.
Son: *(turns the engine crank)* I don't think I've ever seen this before.
Mom: No, *(laughs)* it's part of a car.
Son: And probably before we had um– engines to make these work, when a long time ago, they would probably have to turn this part to make the car work.
Son: That's cool.

(Mom pointed at the crankshaft. Son cranked and looked inside of the crankshaft window again)

Mom: What else do you think they need in there?
What do you see in there?
To keep it moving smoothly.
Son: Maybe like a wheel?
Mom: Yeah– no, see that black stuff? What is that?
Son: It looks like stone.
Mom: Grease
Son: Grease
Mom: Grease to keep it moving smoothly. You see how smooth it turns? 'Cause if you would rub something, like rub something like over and over and over again it would get dried out. Well the grease keeps it moving smoothly.

(Mom looked for sign)

Mom: Well usually they would have something I could read about and tell you how it works-

-----Omit---

[Differential]

(Both mom and son looked at the differential)

Mom: What do you think this is?
Son: You wanna move that?

(Both mom and son looked at the tag)

Mom: This is another car part.

(Mom looked at the wheels and son started to crank and looked at the wheels)

Mom: See, watch how the wheels are turning.
Son: So, the same thing; it has grease on it?
Mom: Well I'm sure, to keep it running smoothly.
Mom: And watch how the wheels are turning.
Son: Yeah the wheels help to move.
Mom: I have to say I don't know much about cars though.
You take for granted what goes on in our car when you turn it on.

As this engagement shows, the mother and son kept failing to identify the exhibit, and their exploration of two car parts did not go beyond seeing what the exhibit does. As the mother did not have much knowledge about how cars mechanically work, she inserted the topic, grease, which she could handle, based on her car-related experience, while interacting with both the engine and the differential. As the mother had difficulties in finding topics to talk regarding the two car parts, she expressed dissatisfaction with their experience by pointing out the lack of information.

Overall, exploration of low knowledge parent-child dyads in the no signage condition at the engine often ended up with simply checking the movement of the crankshaft and pistons. At the differential, low knowledge parents and children simply cranked the handle and observed that both wheels are turned by cranking a handle. Some of the parent-child dyads explored further and observed that the wheels can go either forward or backward. Otherwise, parents focused on features of exhibit (e.g., engine oil, friction of tire, etc) which may not be strongly related to the understanding of how the two car parts work mechanically. Therefore, despite low knowledge parent-child dyads in the no signage condition engaging with the exhibit as long as did other parent-child dyads, they often failed to understand what they observed in the exhibit in regard to how each car part works for a car to move. Low knowledge parents in the no signage condition often reacted either with appreciation for the chance to see the inner workings of car parts or with dissatisfaction about the lack of information on the two car parts.

High knowledge parent-child engagement in the no signage condition

In contrast to low knowledge parents who often failed in identifying the two car parts, high knowledge parents in the no signage condition often started with successful identification of the exhibit. Consider the following engagement between a father and an 8-year-old girl to see how high knowledge parent-child dyads engaged with two car parts differently than did low knowledge parent-child dyads in the no signage condition:

[Engine]

(Dad pointed the engine and looked through the crankshaft window. Daughter started to crank)

Dad: Come here, turn that and watch what happens.
Daughter: *(turns the engine crank)*
Dad: You know what that is?
Dad: That's called a crankshaft.

(Dad moved to the piston window and daughter followed and looked through the piston window)

Dad: Let's see. Look on the other side and you can see what's happening.
Dad: See those things right there?
Daughter: Yeah
Dad: Those are the pistons, and as the pistons turn –
Dad: What happens is up on top of here. There's a sparkplug, and then when the sparkplug fires it blows up inside of here, the gas does, and it pushes the piston down.
Daughter: When will it do that?
Dad: Well that's – this is the part of the engine that – that runs, though.
Daughter: but-
Dad: It makes the car run.
Daughter: But when will it do that – that-
Dad: Well, we don't – you don't have all the stuff on top of here, you're just getting to see how the pistons turn.
Daughter: How come?
Dad: And see, and then when this turns –

[Differential]

(Dad moved to the differential and daughter followed)

Dad: Come over here and I'll show you this.
Daughter: okay

(Dad cranked the handle and daughter looked at the wheels)

Dad: This turns the wheels back here,
Dad: See? And turn this, look at that, look what happens.

(Dad pointed to the engine handle and daughter started to crank the differential handle)

Dad: When that part right there – see where the handle's turning right there?
Daughter: Mmm-hmm
Dad: It turns this shaft back here to the back wheels and a lot happens back there.
Daughter: The motor turns that.
Dad: Well the wheels turn, don't they?
Dad: And that's how you make a car go.
Dad: Is that pretty neat?

In this parent-child engagement, father successfully identified sub-parts of the engine such as the crankshaft and pistons and explained to his daughter what the exhibit designers want to communicate about the engine. However, as the father focused more on explaining how the engine works and used the differential to explain how the engine makes the wheels turn, he did not observe carefully what the differential does. In fact, only 2 out of 7 parents with high knowledge in the no signage condition indicated the independent movement of two wheels.

As this father and daughter interaction showed, parents with high knowledge in the no signage condition were able to address what exhibit designers intended to communicate with visitors about the engine by using their prior knowledge. However, parents with high knowledge were occupied with talking about the exhibit to their children based on what they knew before rather than with carefully exploring the exhibit along with their children. Although parents with high knowledge provided detailed information about the exhibit by using their prior knowledge, there was no difference in time spent for making meaning of the exhibit between the two parent knowledge groups in the no signage condition. High knowledge parents seemed to have a script of what they wanted to say to their children right after identifying the exhibit and before exploring what the exhibit does. Overall, high knowledge parent-child dyads' explorations in the no signage condition seemed to be limited to the parent's interpretation of the exhibit.

Parent-child engagement in the two signage conditions

How did parent-child engagements in the two signage conditions look different from parent-child engagement in the no signage condition? In order to show how differently signage shaped the parent-child engagement in the two signage conditions, three examples of parent-child engagement will be given. Considering the differences in the way to use signage by parent's prior knowledge, one was selected from low knowledge parent-child engagements in two signage conditions and the other was chosen from high knowledge parent-child engagements. In addition, to address how interaction signage was implemented in parent-child engagement in the content and interaction condition, one parent-child engagement from the content and interaction signage condition will be shown.

Low knowledge parent-child engagement in the two signage conditions

In the two signage conditions, the engagements of low knowledge parent-child dyads were often initiated by reading signage text out loud. Unlike in the case of low knowledge parents in the no signage condition, the quantitative analyses showed that parents with low knowledge in two signage conditions identified two car parts more successfully and discussed the exhibits in terms of how a car works and how two car parts make a car go by using information on signage. Consider the following parent-child conversation, showing how a father with low knowledge interacted with a 7-year-old boy about the two car parts in the content signage condition:

[Engine]

(Both dad and son looked at the engine. Son was holding the engine handle)

Dad: We're gunna start –we're gunna start by looking at these two.

Dad: Did we look at these ones before?
Son: No. I don't think this is-
Dad: No?

(Dad skimmed the crankshaft signage. Son also looked at signage with dad along with starting to crank)

Dad: What do you think happens in here?
Son: Looks like – it's like something –it– it goes like around to like do something to the car?
Dad: Yeah what do you think this part of the car does?

(Son pointed to the figure on the crankshaft content sign)

Son: Actually that's the wheels.
Dad: Yeah what does that say? *(Dad points the sign)*
Son: Engine
Dad: Yeah that's the engine.
Son: That's the engine.
Dad: So this is what helps make a car go.

(Dad read aloud the engine identification signage to son. Son looked at the signage along with cranking)

Dad: So, it says here, under the car's hood the engine makes the power that will make the wheels go round, by burning gasoline.

(Son moved to the differential, so dad called son)

Dad: *(Son looked at the differential)* Hey buddy come over here– Wait, let me see.

(Dad explained about signage. Son started to crank while still looking at signage)

Dad: So, see if you turn that – turn that again.
Son: Okay *(turned engine crank)*
Dad: See what happens.
Dad: So if you turn that – and it turns what's called a driveshaft and that's what makes the wheel go 'round. I didn't even know that.

(Dad kneeled down to see the crankshaft signage and pointed to the figure on the signage. Son looked at signage)

Dad: All right, so this says here the spinning crankshaft turns the drive shaft-
Dad:--which is that long thing-
Son: Oh, that's the driveshaft?
Dad: Yeah, which turns the rear axle, which is in your wheel.

[Differential]

(Son moved to the differential. Dad followed son)

Son: Axle, that –you mean it's like-
Dad: Yeah which is there?

Son: It's this one, this– this is an axle.
Dad: Yeah
Son: The axle?
Dad: That's the axle. Yeah, I think your right.
Son: The axle.
Dad: Yeah that's the rear axle right there.
Son: And then? *(turns differential crank)*
Dad: Yeah spin that. So that engine spins this, which then spins your tires.

(Dad read the differential identification signage to son. Son looked at the sign)
Dad: And it says this: In the center of the rear axle, the differential allows two wheels to share power from the engine.
Son: what-

(Dad pointed to the differential and son looked at it)
Dad: It's pointing to that thing.
Son: That?
Dad: This right here. That's called the differential.
Son: The differential
Dad: Yeah
Son: Are these real-

(Dad started to crank the differential handle. Son turned the tire with his hand)
Dad: How fast can it go?
Son: Are these parts from a real car?
Dad: Yeah, they are. If we were to like, look underneath our car, you would see these kinds of parts.
Son: You would see all these parts.

(Dad read signage alone while son turned the wheel by hand. Then dad talked about signage and son looked at the sign)
Dad: Yeah. Oh listen to this, Ben.
Son: What?
Dad: This thing called a differential; you know what it does?
Son: What?
Dad: It allows the two wheels to spin at different speeds.
Son: (Ooo?)
Dad: 'Cause it says when you're on the road– it says, when you're like traveling– like if you're going to go around a curve, the inside wheels would travel a shorter distance and they need to spin slower. And the outside wheels travel a longer distance and they need to spin faster.
Son: I-
Dad: So this helps do that.
Son: I had no idea that– I had no idea that – that this part did that.
Dad: Yeah. I didn't know that either.
Son: That is amazing.

Dad: That is amazing.
Son: Real amazing.

After skimming content signage, the father started a conversation with the son about what the exhibit does and what the car part is. By using text and figures on signage, both father and son identified the exhibit as the engine and talked about its function. The father's and son's investigation of how the engine turns the wheels was linked to the exploration of what the differential does. Beyond observing that turning a handle makes both of wheels go, the father and son successfully identified what the differential is for and why two wheels need to spin at different speeds.

As this father and son conversation about two car parts shows, parents with low knowledge in the two signage conditions were more likely to identify the engine and the differential in terms of where these two car parts are located in a car and how they function. In contrast to parents with low knowledge in the no signage condition who were more likely to focus on what the two car parts do and show, parents with low knowledge in the two signage conditions seemed to see the two car parts in terms of how they related to the mechanism of a car. Therefore, compared to parents with low knowledge in the no signage condition who had difficulties in coming up with ideas about what to talk about and how to explain the exhibit, parents with low knowledge in the two signage conditions, by using signage figures and text, were able to talk about each car part in terms of how a car works.

High knowledge parent-child engagement in the two signage conditions

According to the quantitative analyses, parents with high knowledge in the two signage conditions were less likely to depend on the signage text to talk about two car parts than were parents with low knowledge: Five out of seven parents with high knowledge in each signage condition used the content signage text less than the average rate for each condition. This finding is reflected in the signage using time and signage using action of parents with high knowledge. Parents with high knowledge spent more time on the exhibit (54%) than on signage (29%), while parents with low knowledge in two signage conditions spent more time on signage (47%) than on the exhibit (40%). Parents with high knowledge were less likely to use the content signage text than were parents with low knowledge. However, interestingly, parent knowledge did not affect the rate of signage figure use. The following father and 8-year-old boy's conversation in the content signage condition shows how differently parents with high knowledge used signage in their interaction with children in the two signage conditions than did parents with low knowledge:

> [Engine]
>
> *(Both dad and son looked at the crankshaft window)*
>
> Dad: This is a vehicle, this is what a car looks like, the motor inside daddy's car. If you take it away, if you peal this away, it's a window. You can see how the different things work.
>
> *(Both dad and son looked at the sign)*
>
> Dad: The spinning – this is a crankshaft--
>
> *(Both dad and son found the handle part of the engine and look at signage figure)*
>
> Dad:-- what turns is the– see how that works? All those things turn and turn.
>
> *(Dad pointed the handle and son started to crank)*
>
> Dad: Try turning that thing.
> Son: *(Turns the engine crank)*
>
> *(Dad lifted the sign up and explained to son. Dad explained about the content signage figure by matching the figure with exhibit part)*
>
> Dad: Look at– look at how the motor goes through here and then it hooks up with those drive wheels right there, and basically these things go up and down, turn – turn the driveshaft, see the arrow?
> Son: Yeah
> Dad: And then back of the rear wheels.
>
> *(Dad looked inside of the crankshaft window. Son cranked and looked at the crankshaft window)*
>
> Dad: Keep turning.
> Son: *(Turned the engine crank)*

Dad: Faster, faster. Come on, you got to make the car go fast. Faster.

(Dad pointed the figure on the content signage and son looked at signage)

Dad: Alright, see, this is part of the engine.

Dad: Inside the engine is the crankshaft – this is the crankshaft, that's what's in every car engine, a crankshaft, and that's what turns the wheels.

(Both dad and son moved to the piston side)

Dad: Let's go over here. Right here.

(Dad explained about the piston by using signage figure and son looked at signage)

Dad: That's with the fire right here. That fire burns and then pushes that piston down right here, pushes it down and then creates the– the crankshaft movement, all by itself so you don't have to turn it.

Dad: So boom that fire explodes, you got a little explosion going on right here.

Dad: That pushes this rod down, this whole piston goes down once that explodes, and that makes that whole cranking movement. That's when that blows, that piston goes boom.

[Differential]

(Dad moved to the differential and pointed the handle of the differential. Son looked at the differential)

Dad: Then the next thing, it comes down and turns– it turns this thing, the wheels- turns the shaft.

(Son started to crank and dad read signage alone.)

Son: *(turns the differential crank)*

(Dad pointed to the figure of signage and son looked at signage along with cranking).

Dad: This is called the differential.

(Dad pointed the differential part and son looked at it).

Dad: Right here. It's in every – daddy's truck has got a differential right here.

Dad: The axle goes down,

(Dad pointed to the figure of signage and son looked at the sign along with cranking).

Dad:-- and then there's little gears inside this-- *(pointed to the exhibit, the gear box)* that house it right here.

(Dad pointed to the differential part and son looked at it).

Dad: *(pointed to the gears on the sign figure)*--see those little gears?

Son: Mmm-hmm
Dad: That's what turns.

(Son cranked and dad read signage alone).
Son: *(turned the differential crank)* Like this?

(Son cranked and dad summarized signage content to son, reading sign alone)
Dad: It gives the car power.

(Dad pointed to the figure on signage and son looked at the sign)
Dad: See, from the engine turns the crankshaft, goes into the differential – it's like a gearbox, that's what I call it. And then down through here it goes out the tires and the tires move.
Dad: Is that cool or what?
Son: Yeah.

In this parent-child engagement, the father initiated the engagement with the engine by looking into the crankshaft side window. Like parents with low knowledge in the two signage conditions, this father with high knowledge also used content signage for labeling sub-parts of the engine or explaining how the engine makes the wheels turn. However, as this father and son engagement showed, high knowledge parents were more likely to use the figures on signage as a reference for what they were saying about the two car parts and paid less attention to content signage text than did parents with low knowledge. That is, parents with high knowledge were more likely to make use of signage figures for summarizing their explanation or for labeling parts of the exhibit. Overall, the flow of high knowledge parent-child dyads' exploration of the exhibit depended on how the parent interpreted the two car parts.

Interaction signage usage in the content and interaction signage condition

Along with how differently parents and children engaged with the exhibit in the two signage conditions from parents and children in the no signage condition, the quantitative analyses show the differences in participants' ways of using and talking about the exhibit between the two signage condition: Parent-child dyads in the content and interaction signage condition investigated more deeply what the exhibits have and do. Parents in the content and interaction signage condition were more likely to describe features or evidence of the exhibit and to make inferences about what they observed in more concrete ways. This being the case, how did interaction signage affect parents' and children's exhibit usage in the content and interaction signage condition? Consider the following mother and 8-year-old boy's conversation, which shows how they used interaction signage for their engagement in the content and interaction signage condition.

[Differential]

(After moving to the differential, mom pointed to the differential and son started to crank)

Mom: So this part's – that's the long driveshaft, spins this wheel here.

(Mom looked at the interaction signage and read out loud to him and son also skimmed the sign along with cranking)

Mom: And then this-
Son: What's that?
Mom: It says, look, does a differential have gears inside, and how many gears.

(Mom pointed out the differential identification content signage to son. Son looked at signage)

Mom: Okay, so the differential is this thing in the middle-
Son: Yeah

(Mom read out loud the interaction signage to son. Son looked at signage)

Mom: So what it says is, wait– there are– there are two wheels spinning at different speeds.
Mom: So watch, let's see if they do spin at different speeds.
Mom: Yeah, that one's going faster I think, or is that – no that one's going slower and that one's going faster.
Son: Why?

(Mom read out loud the differential Identification content signage to son. But son looked at two wheels)

Mom: In the center of the rear axle-
Son: Oh yeah
Mom: there's a differential that helps the two wheels share power.

(Mom alone went over to the gear side while son was cranking the handle of the differential)

Mom: So let's see what that looks like. Ohhh,

(Mom and son switched locations)

Mom: Come here – I'll spin that and you look over here.
Son: Okay.

(Mom started to crank and read signage alone and son looked inside of the differential)

Mom: See
Son: hmmm

(Mom read aloud signage to son. Son looked at the inside of the differential box to see gears)

Mom: A car needs a differential –
Mom: I didn't know this –
Mom: The outside wheels travel a longer distance and need to spin faster and the inside wheels travel a shorter distance; they need to spin slower on a curvy road.
Mom: So every car needs a differential that allows two wheels to spin at different speeds.

(Mom moved to the gear side, joined son, and they watched the gears together).

Mom: So what that does, is when you're turning, it allows one – one wheel to go faster and one wheel to go slower.

(Mom read aloud the Gear content signage to son while son looked inside of the differential)

Son: *(matching the content signage figure with gears)* So, there's one on this?
Mom: So it helps it make smooth turns by allowing the two wheels to spin at different speeds.
Son: huh

(Mom and son looked at each other)

Mom: I didn't know that.
Mom: Did you know that?
Son: No
Mom: You learned something new at the museum.

In this parent-child engagement, the mother was often hooked by the interaction signage, which is for prompting visitors to investigate the features and evidences that the exhibit tries to show them, around the differential. The mother read the interaction signage around the differential aloud, and this prompted her and her son to observe the different speeds of two wheels and of the gears inside the differential. Although interaction signage did not affect the way to use the content signage between two signage conditions, the above parent-child engagement showed that interaction signage might successfully encourage parents and children in the content and interaction signage condition to take a close look at the exhibit, and might also help children to encode what the exhibit does as the designer intended. In fact, 14 children in the content and interaction condition indicated the different speeds of two wheels, while in the content signage condition, only seven out of 15 children answered that two wheels spin at different speeds. This difference in use of the exhibit seemed to help children learn better in the content and interaction signage condition.

In particular, interaction signage usage shown in the above parent-child engagement somewhat addresses how the effect of signage condition on a parent-child dyad's learning talk interacted with parent knowledge. As Figure 8 shows , parents with high knowledge in the content signage condition did not address the educational message embedded in two car parts as much as did other parents in the two signage conditions: While only three out of seven parents with high knowledge in the content signage condition noticed the independent movement of two wheels by the function of the differential, seven out of eight parents with low knowledge in the content signage condition and all parents with low knowledge in the content and interaction signage condition noticed the different speeds of the two wheels. On the contrary, parents with high knowledge in the content and interaction signage condition were also more likely to talk about the independent movement of two wheels or about how gears inside of the differential work. Six out of seven parents with high knowledge in the content and interaction signage condition indicated the independent movement of two wheels, and five out of seven discussed how gears work to make the two wheels spin at different speeds.

In fact, no significant differences were found in how parents with high knowledge in the content signage condition explored and talked about the exhibit from how parents with high knowledge in the no signage condition did. Both groups were more focused on the function of the engine and did not deeply explore what the differential is for and how it works, as their exploration of the exhibit was often limited to their own interpretation of two car parts. However, as the above example shows, parents with high knowledge in the content and interaction signage condition were often prompted by interaction signage and opened their exploration to the voices of the exhibit designer. This difference in the way to use the exhibit among parents with high knowledge in the content and interaction signage condition suggests that interaction signage, using a simple prompt for scaffolding parents' interaction regarding what the exhibit shows to visitors, could be a more effective tool than content signage in allowing parents with high knowledge to take in the message of the exhibit designer (or signage writer).

CHAPTER 5

DISCUSSION

The findings of this study will be discussed in regard to understanding the role of signage as an external tool in museum activity in the following two sections: In the first section, how family learning was affected by adding signage to an exhibit and by parents' prior knowledge will be discussed. The second section will discuss how two types of signage content function to make meaning of the exhibit as the main object of a museum activity.

Different Tools and Different Learning

Overall, this study showed that parents and children learned and engaged differently in three different signage conditions. First, both children and parents in the two signage conditions learned more about the two car parts as they made use of signage. Parents in the two signage conditions were more likely to identify and explain the mechanics of two car parts and their sub-parts, and how those parts contribute to a car's movement, than were parents in the no signage condition. Although children were less able than parents to explain how two car parts work, children in the two signage conditions performed better than did children in the no signage condition.

How, then, did parents and children in the two signage conditions perform better at making meaning of two car parts than parents and children in the no signage condition? Could the difference in learning among the different families in three signage conditions be simply that certain parents were more likely to read aloud the information on the signage, thus transmitting that knowledge to their children? First, in order to understand the role of signage on families' learning in the three signage conditions, this study examined how adding signage changed parent-child engagements by considering multiple engagement modes such as attention, action, and talk: This study showed that parents and children in the two signage conditions increased their total time of engagement with the exhibit by the amount of time spent using signage. During the increased time for using signage, parents in the two signage conditions often read aloud the signage text and talked about the figure on the signage. As parents in the two signage conditions used signage content for their talk, differences occurred both in "how much" and in "what" was talked about. The overall amount of parent/child talk increased by the amount they talked about signage in two signage conditions. Parents in the two signage conditions talked more than did parents in the no signage condition. Signage usage supported parents in talking about the exhibit designers' intended educational messages.

In fact, these differences in engagement time and in how much and what families discussed at the exhibit were somewhat expected. Although museum exhibits have been spotlighted as the targeted objects for visitors to interact with and see (Bitgood & Cleghorn, 1994; Stevenson, 1992), exhibits do not always sufficiently support visitors' meaning making. In the no signage condition, where the only information given parents was that the exhibits are inner parts of a car, parents often spent too much time trying to identify the exhibit. Some parents even spent most of their engagement time identifying which part of a car was displayed in the target exhibit. In spite of this effort, parents and children in the no signage condition often failed to identify which parts of a car the exhibit presented. Identifying the object is a critical part of museum learning (Borun et al, 1998), so it is easy to see why these families often failed to figure out what to talk about in terms of the two car parts. Parent-child conversation in the no signage condition usually did not go beyond describing what the exhibit does.

In contrast, parent-child dyads in the two signage conditions actively made use of signage as another meaning making tool in a museum context. Parents and children in the two signage conditions identified the two car parts more quickly and successfully and they explained where the two car parts were located in a car and how they contributed to the car's motion. Parents often used these enriched identifications to extend parent-child conversation about how each car part works beyond the information provided by the exhibit. When families started to look for further understanding of the exhibit's function, signage played a role in enriching the families' conversations by providing ideas about what to talk about at the exhibit. Overall differences in parent-child engagements in the two signage conditions support the idea that well-designed signage could be a tool to help families manage their engagement time more efficiently, enabling a quicker and easier identification of the exhibit, thus allowing families to move on to enriched meaning-making processes.

Analysis of family engagements in three signage conditions showed that using information on signage allowed parents to discuss the exhibit without many of the difficulties they might encounter without the help of signage. This finding proved that signage in this study functioned in the way Hutchins (1990) indicated: tools in the cognitive activity could transform a task for people to easily find the answer or path to a solution. Also, these findings empirically proved that signage could encourage social interaction among visitor groups (Serrell, 1996) and conceptually orient visitors to interpret the exhibit (Screven, 1992), which is assumed, but rarely proven, in the prior museum literature. In general, differences shown in how families made meaning of the exhibit between the two signage conditions and the no signage condition supported the role of signage as a tool to communicate background information on the exhibit.

However, could the difference in family learning be explained only by the role of signage as a communication tool between museums and visitors?

According to the perspective of distributed cognition, not only the external tool but also internal tools should be considered for understanding human cognition (Hollan et al, 2000; Hutchins, 1995; Resnick, et al., 1997). In fact, parents with high knowledge in this study started the engagement with their children knowing most of what the content signage explains about the two car parts, so they may not have depended on signage content to figure out the exhibit's subject and content. That is, if the differences between two the signage conditions and no signage condition simply resulted from transmission of background information on signage, then interaction between two variables—signage condition and parent's prior knowledge—was expected, with the assumption that what parents with high knowledge reported to know before they engaged with the exhibit could also be transmitted to their children. This indicates that to look only at families' use of information on signage may not provide an in-depth explanation of the differences in family learning across three signage conditions, Therefore, this study looked into how prior knowledge of parents as the primary signage readers affected family engagement and learning.

The study's examination of prior knowledge showed that parent's prior knowledge as an internal tool did not support family learning in the way signage as an external tool did. In this study, parent's prior knowledge as an internal tool did not always positively affect family learning. Children with high knowledge parents in the content signage condition, which mostly focused on providing background information about two car parts, did not learn as much as did other children in the two signage conditions. Leaving out, for the moment, children of parents with high knowledge in the content and interaction signage condition, children with low knowledge parents in both signage conditions performed better in talking about two car parts by relating how a car works than did children with high knowledge parents in the content signage condition. Content signage did not help parents with high knowledge so that no difference was found in how much children with high knowledge parents made meaning of two car parts between the content signage condition and the no signage condition. Moreover, parents' belief in their own knowledge seemed to even inhibit parents with high knowledge from exploring and learning new aspects of the exhibit that might not overlap with what they knew. As an example, there was a father in the content signage condition who had experience in taking a car apart but who did not know about the independent movement of two wheels. As this father did not pay any attention to signage and followed his own interpretation of the exhibit, he only used the differential for explaining the effect of what the engine does and lost an opportunity to learn for himself why two wheels on an axle need to spin at different speeds.

Considering these findings, how did parent's prior knowledge as their internal cognitive tool work differently from signage as an external tool for family learning in a museum? Overall, this study showed that parents' prior knowledge allowed parents with high knowledge to have a more exhibit-focused engagement: Parents with high knowledge were more likely to skip the use of content signage text so that they spent less time using signage than did parents with low knowledge. Parents with high knowledge were slightly more likely to manipulate the exhibit in the way the exhibit designers intended than were parents with low knowledge. In conjunction with the action to explore the exhibit, parents' prior knowledge affected the family's way of talking about the exhibit. Parents with high knowledge talked more to identify the exhibit and its parts, made more inferences about the exhibit in a concrete way, and talked about the exhibit by connecting with their prior knowledge or experience than did parents with low knowledge. While parents with low knowledge had to depend heavily on signage to identify and interpret what the exhibit does, parents with high knowledge were more likely to be free to explore what the exhibit does and to interpret what it means by using their prior knowledge.

Considering that parents with high knowledge entered the exhibit already knowing most of the signage content, exhibit-focused exploration of high knowledge parents was somewhat expected. However, an interesting finding is that an interaction occurred between two factors, parent's prior knowledge and signage condition, affecting the degree to which parents and children addressed the educational messages communicated by the exhibit designer. First, parents with high knowledge in the content and interaction signage condition, who also skipped using content signage as much as did parents with high knowledge in the content signage condition, showed the highest learning talk score. On the other hand, parents with high knowledge in the content signage condition did not address the educational messages, which are implicitly embedded in the exhibit and explicitly mentioned on the signage, as much as did other parents in the two signage conditions. Thus, parents with high knowledge in the content signage condition showed even lower scores in learning talk than did parents with low knowledge in two signage conditions. This finding suggests that parents with high knowledge in the content signage conditions may not have paid much attention to the voice of the exhibit designer as a hidden member, and that they remained more focused on transmitting what they know to their children rather than exploring with their children what the exhibit tries to tell them. Thus, they often missed addressing any educational message beyond their own interpretation of the exhibit.

In a museum as an open, free-choice learning context, where visitors are more likely to choose an exhibit to which they can relate personally so that they can make meaning by linking to their prior knowledge or experience (Falk, 1999; Falk, et al., 2001), personal meaning making has been identified as the way of museum learning (Dierking & Falk, 1994; Falk & Dierking, 2001). However, the present study showed that personal meaning making based on a visitor's prior experience and knowledge is not always linked to better learning experience in museums. Parents' prior knowledge is not necessarily linked to the better performance of parents as children's learning partners. In fact, what parents know about the exhibit does not necessarily match what parents think is teachable to their children (Hilke, 1988). Moreover, parents with high knowledge do not necessarily know how best to talk to help children understand what parents know (Gleason & Schauble, 2000). Findings of this study suggest that museums may have to reconsider how to enrich visitors' personal meaning making processes. Low knowledge parents seemed to activate the negotiation process for meaning making of the exhibit with their children by adopting the museum voices on the signage, suggesting that visitor's personal meaning making should be mediated for better family learning experience in museums. It is emphasized as well that parents with high knowledge, who were less likely to attempt to hear another's voice, should also be supported to have better learning experience.

In the interactive museum, where all the exhibits are competing to get visitors' attention (Bitgood, 2003), families' engagement time to explore the exhibit is often affected by children's short attention span (Hilke, 1988). Thus, efficient time management at the exhibit becomes crucial in order for parents to support their children to have a meaningful experience with the exhibit. However, the present study showed that it is not always an easy task for parents to figure out what the exhibit is, what the exhibit is for, and how they can talk and learn about the exhibit. Especially when parents lack appropriate information, their exploration could be limited to checking what the exhibit does. However, this study suggests that museums can make use of signage as a tool for supporting parents in museums so that families can have a better learning experience. Signage can support parents to see more clearly what the exhibit is and what the exhibit is about and to be able to get an idea about what to say, etc.

Despite the field's skeptical view of how often visitors read signs (Brennan, 1977; Bitsgood et al., 1986), this study proved that museums can successfully utilize signage as a tool to communicate with visitors. However, showing differences between two signage conditions and the no signage condition is limited for understanding the role of signage for family learning beyond seeing signage as a tool for providing background information of the exhibit to visitors. In this section, based upon the differences in the way signage as the external tool and parents' prior knowledge as the internal tool work for supporting family learning, the possibilities of other roles of signage beyond transmitting background information on the exhibit from museums to visitors have been raised. In particular, differences in the ways to talk and learn about the exhibit between two high knowledge parent groups in two signage conditions suggest the necessity to look in depth into how two different types of signage content worked differently for family learning. Thus, the following section will discuss about how two different types of signage content made a difference in the way to engage with the exhibit and to learn from it between two signage conditions.

Signage as a Tool for Mediating Exhibit Usage

In the first section, signage is proven as a critical tool for supporting family learning in museums. However, the exhibit is the main object that visitors come to see and interact with in a museum as the object-based learning context. This study focused particularly on examining whether signage can be a tool for mediating visitors' usage of an exhibit as the main object of museum learning in order to further understand the role of signage as a meaning making tool for family museum activity. In particular, to examine whether the addition of two types of signage produced any changes in ways families use and talk about exhibits, this study particularly looked into parents' and children's usage of the exhibit.

In contrast to the effect of signage on total engagement time, adding signage had no effect on how long parents' and children's attention stayed on the exhibit. This finding indicates that the difference in total engagement time among the levels of signage was mostly explained by signage use time. This finding is consistent with a previous study showing that signage reading does not conflict with exhibit viewing time (Bitgood & Patterson, 1993). Moreover, just as it had no effect on time spent using the exhibit, signage did not affect how much parent-child dyads covered of the operation and observational points of the exhibit or how much they talked about the exhibit while their attention stayed on the exhibit. Regardless of signage condition, parents and children actively looked for the interactive parts designed for visitors to manipulate and observe, and they showed a similar amount of talk about the exhibit.

Instead, differences in ways parents and children make use of the exhibit by signage condition were found in how they explored and talked about the exhibit. Parents and children in the content and interaction signage condition were more likely to generate evidence more than one way or to operate the exhibit appropriately, while parents and children in the content signage condition and the no signage conditions were simply cranking and watching what the two car parts do. In addition, parents in the content and interaction signage condition were more likely to describe features and make inferences about how the two car parts work by integrating information from signage and related exhibit parts. On the other hand, there were no significant differences in operating and talking about the exhibit between parents and children in the content signage condition and parents and children in the no signage condition. Parents in the content signage condition were more likely to read content signage aloud and to move on to simply check what the exhibit did without further attempts to integrate information from signage into the exhibit.

These findings from the examination of usage of the exhibit suggest another role of signage: signage can be a successful mediating tool for changing the way visitors make use of the exhibit. However, this role of signage may not be generalized to all types of signage in that differences in usage of the exhibit were particularly found between the content and interaction signage condition and the no signage condition. Given that interaction signage was provided only in the content and interaction signage condition, changing the way parents and children interact with the exhibit could be interpreted as the effect of interaction signage. In other words, interaction signage, which used questions to help families encode evidence informatively and to motivate them to read content signage, may allow parents and children in the content and interaction signage condition to be more active in making integrated meaning from two objects. Interaction signage gives an idea about what participants have to observe and what they can learn from the exhibit. Families with interaction signage were more likely to observe the evidence that the exhibit designer intended to deliver to visitors through the exhibit. In conjunction with participants' exploration of the exhibit, interaction signage affected parents' ways of talking about the exhibit in the content and interaction signage condition.

Unlike previous studies, which indicated that placing questions around exhibits is effective to encourage visitors' signage reading (Hirschi & Screven, 1988), interaction signage did not affect actual reading of content signage. Instead, in the content and interaction signage condition, content signage talk decreased as much as parents' talk to describe features and evidence of the exhibit and to make complex inferences increased. This suggests that questions in interaction signage may connect signage and the exhibit by bringing families' attention from signage to the exhibit, facilitating discussion of the educational message on signage along with observation of what the exhibit does. More frequent usage of complex inference of parents in the content and interaction signage condition in their conversation with children somewhat backs up this possibility. As Bitgood (2003) and Serrell (1996) indicated, adding simple questions to encourage use of signage and the exhibit might more successfully motivate visitor's cognitive arousal. From the view of the social agency theory, interaction signage might facilitate the social conversational mode among parents, children, and the exhibit designer as a hidden member, which might allow families to engage in a deep cognitive process such as organizing and integrating the pieces of information.

If so, could showing the effect of interaction signage on the way to use and talk about the exhibit between two signage conditions explain the interaction effect on learning talk and the differences in children's learning with high knowledge parents in two signage conditions, which is not exactly addressed by the effect of signage as a tool for providing background information of the exhibit? In fact, the difference shown in learning talk between two parents with high knowledge groups in the two signage conditions suggests that the low learning talk score of high knowledge parents in the content signage condition may not be explained only by the low content signage usage rate, in that parents with high knowledge in the content and interaction signage condition were likely to skip using the content signage. Moreover, this study showed that parent knowledge did not affect the usage rate of interaction signage, while parent prior knowledge did affect the reading rate of content signage. These findings suggest that a difference between two high knowledge parent groups in using signage as an external tool is only found in that parents with high knowledge in the content and interaction signage condition made use of the interaction signage for their engagement. This usage of the interaction signage of parents with high knowledge in the content and interaction signage condition may explain the differences in how they addressed the educational message, how they explored the exhibit, and how they supported their children's learning.

Overall, in this study, the effect of signage condition was stronger than that of parent prior knowledge. Although parents' prior knowledge affected the way to use signage and the exhibit, the effect of parents' prior knowledge was more likely to occur within the signage condition. Signage allowed parents with low knowledge in the content signage condition to overcome their lack of knowledge and to show better meaning making of the exhibit than did parents with high knowledge in the no signage condition. Parents with low knowledge in the content and interaction signage condition were also better at supporting their children's learning by addressing the educational message in their conversation with their children than were parents with high knowledge in the content signage condition. That is, the way parents' prior knowledge affects their children's learning could be intermediated by using signage. This finding is consistent with a previous study that showed that visitors' interest can be a factor to predict visitors' signage reading behavior, but not as powerful a factor as the signage design (Bitgood et al., 2006).

If so, how was the interaction signage particularly able to affect high-knowledge parents' ways to use and talk about the exhibit? Based upon the observation of how differently parents with high knowledge engaged in two signage conditions, the interaction signage seemed to take a role of changing parents' way to see the exhibit as an object to engage with. Compared to parents with high knowledge in the content signage condition, who often narrated what they knew and used what the exhibit does as an evidence of what they said to their children, parents with high knowledge in the content and interaction signage condition explored the exhibit together with their children to figure out what museums try to communicate with them. In addition, this difference in how parents see the exhibit as an object for their meaning making process in two signage conditions seems to link to how they play a role as their children's learning partners. In this study, parents with high knowledge who used the interaction signage were more likely to take a role as co-learners who explored the exhibit together with their children to address the questions posed by the interaction signage, rather than taking a directive role to provide educational messages from their own interpretation.

Findings showing differences in how parents with high knowledge engaged with the exhibit in two signage conditions suggest that the interaction signage could play like a bump to encourage parents with high knowledge to refrain from narrating their own interpretation and rather to investigate the meaning of what they were doing in terms of what museums want to say to them. By showing the effect of the interaction signage on parents with high knowledge, this study illuminated that the interaction signage could be a tool for mediating parents' way of using and talking about the exhibit. Especially when content signage failed to get visitors' attention, interaction signage, which was designed as relatively short and easy to be adopted for visitors' conversation, could direct visitors' attention to think about what the exhibit tries to communicate with them. Based upon the finding that parents with high knowledge in the condition where interaction signage is added to content signage became more receptive to embedded learning opportunities, this study suggests that interaction signage could be utilized as a tool to support parents with high knowledge who are less likely to use the content signage.

The importance of investigating the role of signage as a tool for mediating the usage of an exhibit, and of showing its effect on the way families in museums use and talk about the exhibit, is not just that the exhibit is the main object visitors come to see. Instead, that importance is in the discovery that the difference made by the effect of interaction signage on the way to use and talk about the exhibit is actually linked to what children learn. In early museum learning studies focused on children's learning in hands-on museums (e.g., Paris, Troop, Henderlong, & Sulfaro, 1994; Gelman, Massey, & McManus, 1991), children frequently failed in perceiving the critical information of the exhibit and its underlying principles because they often focused only on what they could do with the exhibit and what the exhibit did, without thinking much about its educational content (Paris et al., 1994). However, findings from the present study suggest that simply exposing children to the educational message without linking it to what the exhibit does may not be good enough to support children's learning. In fact, in the present study, children's attention stayed on signage as long as their parents' attention did, as they were looking at the signage while parents read the signage text aloud and talked about the figure on the signage. Some children voluntarily read signage aloud and this stimulated parents' signage reading. Different from parents who were able to make meaning of the exhibit by adopting symbolic information from signage, children learned best in a condition where they were provided the educational message along with appropriate exhibit usage. Children with parents who mostly explored the exhibit and focused on their own interpretation were less likely to learn than were children with parents who used two external meaning making tools in an integrated way.

There is no argument that museum visitors come to see and interact with the exhibit as the main object. Moreover, museum visitors are not obligated to read signage. Whether they read the signage or not is the visitor's choice. However, this study showed that not all visitors could easily and appropriately make use of the exhibit to make meaning of it. Instead, this study showed that visitors, especially children, could learn better when signage mediates the usage of the exhibit by changing the ways of using and talking about it. The effect of differences in exhibit exploration on children's learning in this study demonstrated how important a well-coordinated experience with the exhibit and an appropriate, on-time educational message is for children to learn about the exhibit.

Findings on how differently museum visitors used tools in their hands and how those tools are linked to their learning in two signage conditions support that museums may have to adopt various strategies for various visitors, from children to parents and from experts to novices, in order to exist as family learning contexts. In particular, considering that parents with high knowledge tended to easily overlook what museums want to communicate with them and instead to focus more on sharing prior knowledge with their children, museums need to start various types of signage that can prompt communication between museums and various kinds of visitors. As one possibility, this study showed that interaction signage, which is designed to give brief ideas about what the content signage is about and how to talk about the evidence that the exhibit generates to scaffold interaction, could be used as a way to facilitate negotiation for meaning making between visitors and museums.

Conclusion

Today's museums have developed many ways to meet visitors and communicate with them. Regardless of the type of museum, more museums have adopted interactivity to encourage visitors to be more constructive learners (Adams & Mossouri, 2002). Compared to the exhibit, however, signage has received little attention from museum professionals, despite its having been defined as a communication tool in museums. Moreover, museum signage studies are often limited in addressing how signage functions as a communication tool, or why signage is important to visitors' meaning making, as these studies have focused mainly on how to design better signage to increase the signage reading rate. Therefore, this study was designed to look into how signage is used and how it plays a role especially in family learning contexts.

In answer to two research questions, this study showed that parents and children learned and engaged differently in three signage conditions. Not only children but also parents in the two signage conditions were better able to talk about how two car parts work mechanically for a car to move. Parents in two signage conditions were able to focus on identifying and operating the exhibit beyond examining "what the exhibit can do" and making meaning of it by using information from signage. By having an idea about what to say and how to talk about the exhibit, parents were able to address more about the educational messages in their conversation with children and to thereby enrich children's experience with the exhibit. In particular, signage designed specifically for scaffolding parents' interaction with their children even mediated parents and children to operate and talk about the exhibit in more meaningful ways. When the interaction signage was provided along with the content, parents and children were more likely to generate evidence more than one way or to operate the exhibit appropriately for understanding how two car parts work, and parents were more likely to "describe the feature and evidence of exhibit" and to "make complex inference" about how two car parts work by integrating information from signage to related exhibit parts.

In addition, this study revealed that the way that signage is used could be different by what visitors bring to a museum. Having prior knowledge of the domain of the exhibit often led to an exhibit-focused engagement, which sometimes inhibited parents from taking in the museum's voices provided through signage. This study showed that parents' prior knowledge does not necessarily affect their role as their children's learning partner in a positive way. Compared to parents with high knowledge, who were more likely to depend on prior knowledge or interpretation of the exhibit, parents with low knowledge, who actively made use of information from signage, better addressed the learning opportunities embedded in target exhibits. However, findings show that parents with high knowledge in the condition where interaction signage is added to content signage became more receptive to embedded learning opportunities, suggesting that interaction signage could be utilized as a tool to support parents with high knowledge who are less likely to use the content signage.

Throughout these findings, this study showed that signage is as important as the exhibit especially for parents who cannot always easily find out what the exhibit is, what the exhibit designers want to communicate with visitors, and “what” and “how” to talk about the exhibit to their children. From identifying what the exhibit is to understanding what the exhibit does and why, signage in this study guided parents about how to talk and what to say. That is, adding interactivity to the exhibit does not always guarantee a better learning experience for parents or children, who may not be familiar with ways to talk about the exhibit or ways to engage with the objects. Through looking into the role of signage in a family learning context, this study helped us reconsider how to support families to have a better learning experience in museums. This study suggested that signage could be a tool to provide practical support for families to think and talk about the exhibit beyond what they could do without such a tool.

Once visitors start to seek and read a museum’s message from signage, negotiation for making meaning of the exhibit between visitors and the museum begins. In other words, signage could be a channel for the exhibit designer to participate in visitors’ activity. Yet despite signage having been defined as a communication tool between museums and their visitors, museums have limited signage to the function of providing background information on exhibits without further consideration of how exhibit designers to participate as hidden members of visitors’ meaning making process. Findings from the exploration of two types of signage content in this study revealed that signage should be a channel for museums to involve in visitors’ meaning making process and suggest that more considerations are asked to make use of signage a tool beyond presenting what they want to inform to their visitors.

Considering that two types of signage content explored in this study could be defined and designed in various ways by seeing signage as a designed artifact, so that findings from this study may not be generalized to any type of exhibit or any kind of museum. Moreover, it has not still known much about what kinds of information visitors want to see on signage or what kinds of signage content could be developed and utilized in museums as a family learning context.

Nevertheless, it is certain that this study showed the possibilities of using signage could be a way to create a museum into a better family learning context. Therefore, findings of this study suggest exploring further how signage could be used as a tool for better communication between museums and their visitors.

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Footnotes

[1] In this study, parents who know at least how the engine works for a car to move (scored over 5 points at the self-reported prior knowledge measure) are defined as high knowledge parents. Seven high knowledge parents and eight low knowledge parents were targeted in each condition. Given that parents' prior knowledge was measured after they engaged with the exhibit to avoid the priming effect on parents' interaction with exhibits by the pre-interview, three parent-child dyads had to be dropped due to balancing target numbers of each parent knowledge group in three conditions. Six parent-child dyads were dropped because they did not complete the whole experimental procedure or because younger siblings interrupted the engagement. One parent-child dyad was dropped because the parent speaks English as a Second Language.

[2] Compared to parents, children interviewed after the engagement with the exhibit had difficulties in explaining how two mechanical car parts work However, the total score of children ranged from 0 to 10.5 points. Children who were more familiar with inner car parts were more likely to learn from the activity at the target exhibit and more able to explain how two car parts work. Thus, some of children were able to get higher scores than the mean score in each condition.