Learning in Children's Museums: Is It Really Happening?

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ABSTRACT **This study examined what children learn while they are interacting with exhibits at a children's museum as well as the conditions that facilitate learning. Using naturalistic observations to get information on the kinds of observable learning that occurred in a variety of settings within the museum, the study found that much observable learning did occur and that different contexts supported different kinds and amounts of learning. Learning was more likely to occur with adult interaction than without, and certain types of exhibits invited more adult involvement than others. Examples of learning of relatively higher levels of cognitive complexity and higher degrees of generalizability were observed more rarely than examples of learning of lower complexity and less generalizability. Implications for children's museums and other settings of informal learning are discussed.**

INTRODUCTION

In the last few decades children's museums have become an increasingly popular attraction for family and school groups (Lewin 1989). Generally designed as centers of informal, child-centered learning, children's museums can be contrasted with traditional museums in their emphasis on direct, hands-on interaction with exhibits (Lewin 1989; Ramey-Gassert et al. 1994; Farmer 1995; Schauble and Bartlett 1997; Please Touch Museum 1998). Children's museum educators customarily take a Piagetian view that children learn best through active involvement with their environment and through first-hand concrete experiences (Piaget 1977). This view also follows from work and

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theories of Howard Gardner who believes that informal environments like children's museums provide a context where children can learn easily from multiple modalities (Gardner 1991, 1993). Museums, argues Gardner, engage children, and allow them to take responsibility for their own learning. Museum experiences may also be social experiences which motivate children and allow learning to take place in the context of doing things (Borun et al. 1995; Gardner 1991, 1993; Lewin 1989).

Although children's museums are intended to provide learning experiences for children, and are often assumed to do so (Siach-Bar 1998), the assumption of learning through experience may not be adequate. In particular, important questions concerning how much children actually do learn while interacting with exhibits, what kinds of learning occur, and what the role of social interaction is in learning in children's museums remain largely unanswered.

Previous studies indicate that changing certain aspects of exhibit experiences at hands-on museums affects learning. For example, altering the appearance, legibility, wording and other aspects of exhibit labels in science museums has been shown to increase the comprehension of exhibit-related information in children, teenagers, and adults (Falk 1997; Kanel and Tamir 1997). Another study found that use of a computerized audio-videotape to describe the purpose and intended use of an exhibit for children was more effective than a written sign in facilitating science learning (Gelman et al. 1991). Other studies indicate that involving visitors in scientific inquiry activities in science museums has an impact on learning, and that certain types of activities are more effective in facilitating comprehension of scientific concepts than others (Allen 1997; Stevens and Hall 1997). Finally, one study found that modifying exhibits to make them more attractive to families increased learning-related behaviors of family members (Borun et al. 1997).

Although these and other studies show the potential for learning in informal museum settings, most do not make a focused effort to determine how much and what kinds of learning occur in the museums as they are. An exception is the study by Falk (1997), cited above, which used a pre- and post-test design to determine whether learning occurred at two science exhibit clusters both with the original and with enhanced exhibit labeling. The study found that even with the original exhibit labels post-test scores were significantly better than pre-test scores at one of two target exhibits.

Social interaction is a possible important factor in learning in children's museums. Children's museums are social places, providing a context for learning that is mediated by interaction with others (Borun et al. 1995; Lewin 1989; Please Touch Museum 1998). In this respect they have the potential to provide the social experiences which Vygotsky and others have proposed are essential for learning. Vygotsky (1978) believed that children learn best when presented with tasks that they are unable to complete independently but that they are capable of completing through interaction with other, more skilled individuals. Others have expanded on Vygotsky's ideas and have used the term scaffolding to refer to the verbal and nonverbal guidance provided by adults when assisting children at tasks (Bruner 1985; Wood 1980; Wood et al. 1976). This type of learning is also consistent with theories of situated cognition, which posit that real-world learning is contextualized and heavily shaped by socio-cultural mediation (Greeno et al. 1993). The apprenticeship model of teaching and learning advocated by situated learning theorists is based partly on Vygotsky's theory and the notion of scaffolding which followed from it (Woolfolk 1998).

Studies in school and other everyday contexts support the notion that scaffolding is important in children's learning (Fleer 1992; Greenfield 1984; McNaughton and Leylan 1990; Palincsar 1986; Pratt et al. 1992). In informal museum settings, the research cited above by Allen (1997) and Stevens and Hall (1997) about scientific inquiry, may be viewed as studies of the use of verbal scaffolding to enhance learning in museum visitors. In the latter study, a researcher showed visitors a videotape of their interaction with a science exhibit and discussed the experience with them, and in the former a knowledgeable researcher verbally guided science museum visitors with inquiry activities.

Other research has focused more directly on scaffolding of children's learning in museums. In one study, researchers examined the discourse of eight- to nine-year old children as they visited a London science museum (Gilbert and Priest 1997). The children explored a series of exhibits in groups of four, each accompanied by a knowledgeable adult. The researchers found that during and after the visit many bits of learning-related discourse occurred, but concluded that an essential ingredient for this learning was the sustained participation of a knowledgeable adult. Another study in a children's museum found that parents provide children with different kinds of support depending on the type of exhibit (Gelman et al. 1991). Parents were more likely to teach children information in a grocery store exhibit than they were in an exhibit about gears and inclined planes. The researchers believed the difference pertained partly to differences in the parents' perceived competence in the two areas, and the fact that parents may believe they should leave the teaching of school-related topics to the schools (Gelman et al. 1991). More recently, Crowley and Callanan have provided evidence of how parents through active engagement influence and support children's scientific thinking (Crowley and Callanan 1998; Crowley et al. in press). This engagement was shown to significantly increase the child's opportunity to learn.

There has been a proliferation of children's museums in the last thirty years, and exhibits in children's museums are generally designed with learning in mind. Some research does exist on learning in hands-on, informal settings. However, the overwhelming majority of existing studies took place in science museums (Borun et al. 1996), and with children over age seven (an exception is the study by Gelman et al. 1991). Many existing studies tend to involve the manipulation of some aspect of the museum experience to determine its effect on learning, or to assume that learning occurs, thus focusing on the *potential for* learning to occur, rather than on whether learning *tends to* occur. The current study can be contrasted with previous research in several ways. It took place in a children's museum rather than a science museum, and focused on very young children, aged four and five. It also concentrated on what actually happened when children interacted with existing museum exhibits, rather than on what might occur given certain conditions. Thus it gives a more realistic assessment of whether children learn and what they learn in children's museums. It also addresses the role of scaffolding in the learning that occurred.

More specifically, the goal of the current study was to examine what kinds of learning occurred by four- and five-year olds at a children's museum, how often learning occurred, and what the contexts were surrounding this learning. Because the objective of the study was to examine the general assumption by museums that children learn at exhibits, researchers used a variety of conceptions of learning in order to operationalize it. At the same time, the fact that the study relied on naturalistic observations restricted researchers to aspects of learning that could be directly inferred from children's natural behavior.

The study used a cognitive perspective which holds that learning involves a change in mental representations due to experience that may or may not be manifested in behavior (Bruer 1993; Eggen and Kauchak 1997). To determine whether learning had occurred, then, researchers either made direct inferences about learning based on observable changes in behavior, or they used more indirect methods of inferring learning. In the former case, if a child initially made errors or had difficulty solving a problem, received feedback, and then made fewer errors or solved the problem, learning was assumed to have occurred.

Researchers used Piaget's theory of equilibration to make more indirect inferences about learning. According to Piaget, when a child encounters an experience which they cannot assimilate into existing mental representations or schemes, they enter a state of disequilibrium. Disequilibrium is undesirable, so the child attempts to create equilibrium by adjusting existing schemes to accommodate the new information (Ginsberg and Opper 1979). This process is consistent with cognitive theories of motivation, which believe that people have an innate need to understand the world around them (Eggen and Kauchak 1997). Hence inferences about learning were made when children's behavior indicated a desire to understand a situation and in response was provided with necessary information from the environment to fulfill that desire. In addition to learning itself, the study also examined scaffolding, or attempts by accompanying peers or adults to support learning by a target child.

It should be noted here that the basic goal of the study is to examine one assumption held by children's museums, which is that learning occurs while children engage in exhibits. The researchers recognize that there are many other possible outcomes of exhibit interaction that were not examined in the study, such as development of creativity, general social interaction, and play. It is also clear that much learning of a less observable nature or according to different conceptions of learning may have occurred during children's interactions with the exhibits that is not recorded in the study. However, although the study was not able to record every possible valuable outcome of children's interactions at the museum, it takes the important step of beginning to define how museum behavior related to learning occurs rather than continuing to assume that learning takes place. (See Borun et al. 1996, for another example of research which uses behavior at exhibits to infer learning).

METHOD

Setting—The study took place at Please Touch Museum, a museum for children aged one to seven located in Philadelphia (Figure 1). Founded in 1976, the museum is designed so that children and adults can learn and explore together, using hands-on exhibits, programs and collections. The museum attracts a diverse racial and socioeconomic sample of visitors in both family and school groups. It houses both permanent and temporary exhibits and contains a store that sells books, toys, and other items related to its exhibits.

Sample—The sample comprised 101 four- and five-year old Please Touch Museum visitors. The sample was not random, since researchers only included children who remained at target exhibits for at least 60 seconds, attempts were made to collect a racially diverse sample, and researchers tended to collect data during peak museum hours.

Table 1 presents demographic characteristics of the sample. Approximately equal numbers of boys and girls participated. Sixty-one percent of the sample was white, 34 percent was African American and 5 percent comprised other races. Slightly over half of the study participants were in family groups at the museum and slightly less than half were in school groups; about two-thirds of the sample were with parents or grandparents during the observations, 16 percent were with a teacher, 13 percent were with no caretaker, and 8 percent were with a caregiver who was neither a parent, grandparent or teacher.

Figure 1. Children act as cashiers and consumers at the Grocery Store exhibit. *Photo courtesy of Please Touch Museum.*

Table 1. Characteristics of the sample (N=101)

Gender	Race	With family or school group	Type of caretaker present at exhibit
52.5% boys 47.5% girls	61% white 34% African-American 5% other	54% with family groups 46% with school groups	62% parent or grandparent 16% teacher 13% no caretaker 8% other 1% no data

Procedure—Eight target exhibits were chosen based on pilot observations and discussions with Please Touch Museum staff. Criteria for exhibit choice were popularity among the target age group, possibility for a wide range of learning to take place, and a tendency for children to stay at the exhibit for at least one minute. The list of exhibits chosen and a brief description of each is presented in Table 2.

Data were collected in the form of prose observations that were recorded by hand on the spot at target exhibits. A researcher stood by the exhibit and waited until an appropriate-age child entered the exhibit area or began interacting with the activity. The researcher then took down a written record of what the target child did and said while at the exhibit, as well as what others did and said in interaction with the child. Observations ended when the target child left the activity. The observations were timed, and only those that lasted more than 60 seconds were included. The researcher verified the age of the child following the observation by asking the child or an accompanying adult, and children who were between three years nine months and five years three months of age were included in the sample. At least six boys and six girls were observed at each exhibit, for a minimum of twelve children at each of the eight exhibits. Two researchers shared the responsibility of observing and recording, with each individually recording approximately half of the observations. Recording agreement between the two researchers was assessed at 0.89. Following data collection, observation records were coded for type of learning and for scaffolding. Interrater reliability for coding was assessed using Cohen's kappa and was found to be 0.82.

Learning—As stated earlier, the study used a cognitive perspective, which views learning as a change in mental representations due to experience that may or may not be manifested in behavior. Since researchers were relying on naturalistic observations, however, for observers to determine that learning had occurred children needed to either directly or indirectly indicate via their behavior at the exhibit that they had learned something. The most direct indication of change in behavior due to experience occurred when (while at an exhibit) a child solved a problem incorrectly or made errors (initial behavior), was given feedback from the environment (experience) and then subsequently made fewer errors or solved the initial problem or a similar one correctly

Table 2. Target exhibits

Exhibit	Description
City Bus	Front section of an actual Philadelphia city bus, with driver's seat, steering wheel, pedals, front door, buttons and switches. Some of the buttons and switches make realistic noises or cause lights to flash on dashboard.
Grocery Store	Child-scale model of a grocery store, with one aisle and two checkout counters with registers. Shelves are stocked with actual food containers (empty, coated with plastic) and plastic vegetables, fruit, etc.
Kitchen	Two child-scale model kitchens, each with sink, refrigerator, oven, stove, cabinets, shelves, pots and pans, bowls, measuring utensils.
Pegafoamasaurus	Large white pegboard accompanied by foam pieces of different shapes and colors. Object is to mount foam pieces on board to create pictures/patterns.
River	Large water-filled table area meant to represent section of the Schuylkill River. Features loading dock equipped with cranes. Trucks and boats are available for loading magnetic crates using cranes. One end of river has a train and ferry boat which move across the river when knob or lever is manipulated.
Rollaway	Vertically mounted board with grooves, accompanied by small balls and box of slats (of different colors and sizes). Goal is to put slats in board to create different pathways for balls to go down.
School Bus Fieldtrip	Interactive video which allows children to visit three different locations (suburban, urban, rural) and see how children play in the different regions. In reaction to video, children press buttons to choose direction of travel, location they want to visit, activities they would like to observe.
TV Studio	Model TV production studio, with control area, stage, TV camera, and monitors. Children can stand on stage and see themselves on TV; can also use a button to select different TV backgrounds.

(change in behavior). An example of this type of event can be seen in the following transcript from an observation at the School Bus Fieldtrip exhibit. In the transcript a child begins interaction at the exhibit with much random button-pushing activity, which he subsequently reduces as his mother teaches him to wait for the video to provide choices before making a selection and then pushing the corresponding button:

> Child (C) pushes buttons randomly . . .
> [M tries to get turn-taking scheme going with C and sister.]
> M: OK, let's see what the next question is.

C keeps pushing the buttons between questions, agitated over sister's presence.
M: There's nothing to push yet so you're getting upset over nothing.
Video asks a question. M repeats the question.
C: Hopscotch.
Sister pushes hopscotch button.
C pushes a different button. It's too late; video started showing hopscotch scene.
C is unhappy about that but watches video without pressing buttons.
Adults tells C that when the video asks the next question, it will be C's turn to push.
Video asks question, C pushes a button.
[Observation continues, then the following exchange takes place near the end of the observation.]
C does not interfere as Sister pushes button and pays attention to video's response.
For the next choice, C waits for the question, decides, and asks M what button to push.
M tells C, and C pushes it.
C watches the video a little bit more, then gets up to go.

A second way for a behavior to indicate learning occurred when children changed their behavior in response to verbal and/or nonverbal information provided by another person. Labeling this type of event "learning" requires more inference than the preceding example, as there is no direct evidence of an initial incorrect behavior. However, since the change in behavior is a direct result of experience, learning can be reasonably inferred. Examples of this type of event would be a child using a toy crane with a magnet to pick up crates from a truck following a demonstration by his mother, or a child removing a pretend ravioli package from the stove burner in the kitchen after her mother tells her that putting the package there could cause a fire.

While observing behavior change linked to specific experiences may be the most direct way to determine learning, relying on this type of event would likely have seriously underestimated the amount of learning that occurred. Hence, as indicated earlier, the study also relied on observable attempts by the child to move from a state of disequilibrium to equilibrium. One observable indication that a child is attempting to gain understanding in this manner is the asking of questions. In the study, when a child asked a question (attempted to move from disequilibrium to equilibrium) and was provided an answer (the means to move to equilibrium), it was inferred that learning had occurred. For example, in one case a child held up a pretend potato from the kitchen, asked the father, "What's this?" and the father said, "Potato." In another instance a child asked his mother how to cook fish, and she explained that you put it in a pot and then place it in the oven.

Not all attempts to understand new experiences will be expressed verbally. Nonverbally, simply acting on the environment and obtaining and attending to a causal result, while not a direct indicator of learning, may also be inferred to involve learning,

Figure 2. Children enjoy driving and riding on the City Bus at Please Touch Museum. *Photo courtesy of Please Touch Museum.*

especially when it occurs in the context of active exploration and involvement, since those are times when a child is highly attentive. Hence learning was considered to have occurred when a child acted on the environment and received a reaction as a direct result of their action. Examples of this type of learning included a child moving the lever at the River exhibit and watching the train move across the bridge as she does this, or pushing a button inside the City Bus and causing the horn to sound (Figure 2).

In summary, then, to be coded as learning one of four different types of events had to occur, as follows: 1) initial errors or difficulty solving a problem, followed by feedback, followed by fewer errors or solving the problem or a similar one correctly; 2) verbal feedback from an adult followed by a corresponding change in behavior; 3) child asking a question and receiving and attending to a response; and 4), child acting on the environment and obtaining and attending to a causal effect.

Learning events were then further subdivided into different types of learning. The first type of learning listed is simple cause and effect (Table 3), which was the learning of the physical relationship between an action and a result. Examples of this form of learning include winding up a boat and then watching it move on the water as well as the lever and button-pushing examples given earlier. Simple cause and effect, although relatively common (see Results section), may be the least interesting type of learning examined as it involved simple physical relationships. Further, although these

Table 3. Types of learning

Learning	
Simple cause and effect	C learns the physical relationship between an action and a result. Evidence that C has noticed the effect or result must exist.
Small motor	C develops small-motor skills.
Information–Script	C learns about the sequence of actions or the objects used during an event such as grocery shopping or cooking. Child (C) learns a piece of information (C asks question and answer is provided, or Adult (A) provides information with clear evidence that C attends to it).
Information–Categories	C learns about classes or groups to which items or concepts belongs.
Information–Factual	C learns information that is related to neither script nor categories
Procedure	C learns the particular way of accomplishing something or of acting.
Conceptual cause and effect	C learns or gains an understanding of the conceptual nature of a cause and effect relationship, or of the relationship between items or actions in a script or in a procedure.

cause/effect events were engaging for the child, they tended to be specific to the museum context.

The next type of learning listed is motor learning, which occurred when a child's motor skills improved as s/he interacted with an exhibit. Examples of small motor learning occurred when children had initial difficulty placing slats in the board at the Rollaway exhibit or pressing the buttons effectively at the School Bus Fieldtrip exhibit but did it with improved facility at the end of their interaction with the exhibit. This type of learning may be more generalizable outside the museum context than simple cause and effect, but because it is motor-related rather than cognitive the researchers considered it a relatively simple form of learning. More interesting for the researchers was information learning. This form of learning was more generalizable outside the museum context than simple cause and effect since the information learned had applications in the real world. Information learning was subdivided into three kinds: script learning, when learning involved part of a script activity; categorical learning, when the event concerned classes or groups to which items or concepts belonged; and factual, when learning involved facts unrelated to scripts or categories. Following is a transcript of an observation which involved information learning of the script variety, as a child is carrying out a sequence of actions and verbalizations related to cooking, accompanied by guidance from his mother. In the transcript are three different events that were coded for learning according to the specifications described above. These individual events have been placed in { }:

[Child (C) brings full cart from grocery store into the kitchen.]
Mother (M): Oh, where does all this stuff go?
{C puts can in the freezer.
M: Does that go in the freezer?
C: Fridge (puts can in the fridge).
M: Noooo
C: Here (puts soup can on shelf).
M: Yeah, that's right.}
[They go through same routine with rest of groceries. M prompts a bit.]
{C: Does the fish go in the freezer? (C puts fish in freezer).
M: I think so.}
{C puts tomato sauce can in fridge.
M: Does Mommy put cans in the fridge?
C: Yeah.
M: No.
C: It's tomato sauce.
M: We only do it after it's open.
C puts tomato sauce can on the shelf.}

Another generalizable type of learning was procedural learning, whereby the change in behavior or question concerned carrying out a procedure. The transcript from an observation of the School Bus Fieldtrip, provided earlier, is an example of procedural learning as the child learned the appropriate procedure for using the exhibit. The last type of learning listed is conceptual cause and effect, whereby the behavior change involved understanding the conceptual relationship between two things or ideas (such as might occur in a problem-solving task). An example of conceptual cause and effect can be seen in the following transcript, which shows a child at the Rollaway exhibit working on creating a pathway for the ball to go down:

Child (C) starts the ball rolling from the top of a ramp. The ball goes too far off the end of one ramp, and falls to the floor instead of continuing down the other ramps.
Father (F): OK, let's do this (as he puts in a vertical barrier to keep the ball from dropping to the floor instead of the ramp).
C starts the ball again and it goes all the way down the ramps.
C starts to extend one ramp, and makes the ramp go all the way to the side of the board.
F: No, don't do that or the ball won't drop. Need to leave a hole.
C leaves a hole.
[Observation continues for a while, with F providing more verbal and physical guidance, then the following exchange takes place near the end of the observation.]
C makes a new ramp in between two other ramps using only red pieces.

F is observing him.
C finishes the ramp.
F: Try using the ball to see what happens.
C puts the ball in the ramp, but a red slat blocks the ball so it can't go onto the ramp. C takes one slat out so that the ball can go onto the red ramp, tries the ball, and it works, going onto the red ramp.

As mentioned earlier, adult scaffolding was also recorded in the study. An event was coded as scaffolding whenever an adult interacted with a child verbally or nonverbally in an attempt to directly facilitate the child's exhibit-related interaction. Many acts of scaffolding occurred during learning events, and each of the transcripts showing examples of learning inserted earlier in the paper also include examples of adult scaffolding. Not all instances of adult scaffolding were accompanied by or resulted in learning however. Following is an excerpt from an observation at the River which shows adult scaffolding that is not accompanied by sufficient evidence that learning has occurred:

Mother (M) hands truck to C
M shows C how to use crane magnet to pick up blocks from truck
C: I wanna put this truck in the water
C puts truck in water
M: What would happen if you put a real truck in water? Would it break?
C: [inaudible]

In addition to coding for adult scaffolding behaviors that occurred as the target child interacted with each exhibit, each observation was also coded for the *amount* of adult involvement that occurred. Immediately following each observation the record was given one of three codes: adult not involved; adult somewhat involved; or adult highly involved. The criteria corresponding to each of these codes are listed in Table 4.

One final type of behavior that researchers coded is exploratory or expressive behavior in which children either seek understanding without appearing to receive adequate feedback from the environment or engage in expressive behaviors, such as carrying out a script, monologuing, or explaining ideas to others. Vygotsky (1962, 1978) believed that such behaviors are essential components of cognitive development, as they are ways for a child to practice and consolidate social behaviors, concepts, and language. This type of behavior, which the study refers to as learning in progress, was considered important but was not close enough to our definition of learning to be coded as such. Examples of learning in progress include a child verbally describing his/her actions to another person, a child verbalizing to him/herself during an activity, a child asking an exhibit-related question without receiving a response, and a child attempting to solve a problem without succeeding.

Results—Findings concerning learning, learning in progress, scaffolding, time spent at target exhibits (time on task), and amount of adult involvement are reported below. It

Table 4. Physical criteria for adult involvement codes

Highly involved	Somewhat involved	Not involved
Adult (A) verbalizes frequently to Child (C) in relation to task A provides physical demonstration (s) to C A physically or verbally facilitates task for C A remains physically close to C	A is present, and A verbalizes, scaffolds, or facilitates for C, but infrequently	A is not present A is present but does not watch C A is present but remains physically distant enough to preclude verbal or physical interaction A does not verbalize to C in relation to task, and neither physically nor verbally scaffolds, facilitates

should be noted that for statistical analyses the researchers combined two exhibits, the Grocery Store and the Kitchen, since the two areas were adjacent and children tended to move back and forth from one to the other continuously.

Learning. Each type of learning was considered a variable. For each observation, the number of instances of a type of learning or the presence or absence of the type of learning was recorded, depending on the variable. For an instance of a type of learning to be recorded, it had to be a new example of that kind of learning. For example, using the horn on the City Bus was considered simple cause and effect learning, as was making the dashboard light up by flicking a switch. If a child honked the horn several times during the observation, it was recorded as one instance of simple cause and effect. If she honked the horn and used the switch that made the dashboard light up, it was recorded as two instances. Each type of scaffolding (corresponding to each type of learning) was also considered a variable. For scaffolding variables a rough estimate of the number of scaffolding events was recorded. There also existed variables for the sum of all learning that occurred, and the sum of all scaffolding that occurred for each observation.

Table 5 shows the mean number of instances of overall learning and scaffolding that occurred for each exhibit as well as a mean rate for number of instances of learning per minute. As can be seen in the table, at least one instance of learning occurred per observation for most of the exhibits. The study found the highest number of learning instances per observation at the Rollaway, with an average of 1.7 instances of learning per observation. However, in terms of rates of learning per minute, the City Bus was higher, (which means that average time spent at the Rollaway was longer). At one exhibit, the Pegafoamasaurus, almost no learning was recorded.

Scaffolding occurred at higher rates than learning at each exhibit. Number of instances of scaffolding varied widely, however, ranging from the School Bus Fieldtrip with an average of 6 instances per observation to the Pegafoamasaurus which had less

Table 5. Mean amounts and mean rates of learning, and scaffolding for each exhibit

Exhibit	Learning		Scaffolding	
	Mean	*Mean rate per minute*	*Mean*	*Mean rate per minute*
City Bus	1.385	.522	1.538	.580
Grocery/kitchen	0.913	.116	4.391	.556
Pegafoamasaurus	0.083	.028	0.250	.086
River	0.857	.211	1.143	.281
Rollaway	1.714	.440	2.429	.624
School Bus Fieldtrip	1.000	.310	6.308	1.952
TV Studio	1.583	.388	2.000	.490

than 1/4 of an instance per observation. Another exhibit with a high numberof instances of scaffolding was the Grocery/kitchen.

Table 6 shows the mean number of instances of each type of learning that occurred at each exhibit, plus mean rates of that type of learning (learning per minute). As can be seen in the table, a wide range of learning was observed. Some types of learning, such as simple cause and effect, occurred at most of the exhibits with relatively high rates of frequency. Other types, such as conceptual cause and effect and script learning, were quite rare. Equally clear is the fact that while some exhibits, such as the Rollaway, the School Bus Fieldtrip and the Grocery/kitchen, seem favorable to a wide range of types of learning, exhibits such as the Pegafoamasaurus, the River, and the TV Studio, show relatively few types of each.

Pearson correlations were carried out to determine the relationship between learning and scaffolding (Table 7). Learning and scaffolding were significantly positively correlated with each other overall and at every exhibit except for the City Bus and the Pegafoamasaurus.

learning in progress. learning in progress occurred at all exhibits, with the most occurrences at the Grocery/kitchen and the City Bus. The most common form of learning in progress was script expression, whereby children acted out the sequence of events related to activities such as grocery shopping or cooking. The correlation between learning in progress and scaffolding is weaker than that between learning and scaffolding, but is statistically significant ($r=.28$, $p<.01$).

Time on Task. ANOVAs were carried out to determine whether there were differences in time spent at exhibits as a function of the various background variables, and as a function of the amount of adult involvement. The sample included only observations of children who spent at least 60 seconds at an exhibit, so logically the minimum time

Table 6. Mean no. of instances and mean rates (per minute) of types of learning for each exhibit

Learning type /exhibit	**Rollaway**		**School Bus Fieldtrip**		**River**		**City Bus**		**Pegafoamasaurus**		**TV Studio**		**Grocery/ Kitchen**	
	Mean	*Mean rate*	*Mean*	*Mean rate*	*Mean*	*Mean rate*	*Mean*	*Mean rate*	*Mean*	*Mean rate*	*Mean*	*Mean rate*	*Mean*	*Mean rate*
Simple C & E	1.00	.257	.231	.071	.571	.140	1.077	.406			1.5	.367		
Small Motor	.214	.055	.154	.048										
Script					.154	.058							.087	.011
Categories													.565	.072
Factual			.143	.035	.077	.024	.083	.02	.261	.033				
Procedure	.357	.092	.538	.167	.143	.035			.083	.028				
Conceptual C & E	.143	.037	.077	.024										

Table 7. Correlations between learning and scaffolding for each exhibit

	Correlations: learning with scaffolding (Pearson r values)	Probabilities
All exhibits	.567	.000
Rollaway	.839	.000
School Bus Fieldtrip	.802	.001
River	.792	.001
City Bus	.281	.353
Pegafoamasaurus	.522	.082
TV Studio	.717	.009
Grocery/kitchen	.706	.000

spent at an exhibit was one minute. The maximum time spent was 39.5 minutes, with a mean time spent of 4.5 minutes. When five outliers who spent significantly more time than others at particular exhibits are excluded, the maximum time spent was 16 minutes, and the average time spent was 3.82 minutes. (Unless otherwise specified, outliers were eliminated from all results reported below concerning time on task). No significant differences were found in time on task between genders overall or at each exhibit, and no significant differences were found in time on task overall according to race or different types of caretakers.

In terms of amount of adult involvement, mean time on task was significantly higher for observations coded highly involved than for somewhat involved or not involved ($F=8.45$, d.f.$=2$, $p<.001$). For highly involved, mean time on task was 5.13 minutes, for somewhat involved the corresponding mean was 2.88 minutes, and for not involved it was 2.28 minutes. No significant difference in time on task was found between somewhat involved and not involved.

ANOVA analyses show a statistically significant difference in the number of instances of overall learning as a function of gender, with more learning occurring for boys. (For learning, $F=6.73$, d.f.$=1$, $p<.05$). When learning is broken down by exhibit, there is a statistically significant difference at one exhibit, the Grocery/kitchen, where boys learned more than girls ($F=7.20$, d.f$=1$, $p<.01$). No differences were found in scaffolding as a function of gender overall or by exhibit. No significant differences for overall learning were found as a function of race at any exhibit.

Time on task was found to be significantly positively correlated with learning overall ($r=.46$, $p<.001$) and at each exhibit except for the Pegafoamasaurus, which had almost no learning, and the River. With scaffolding partialled out, a correlation between time on task and learning overall still exists ($r=.30$, $p<.01$). learning in progress was also found to be positively correlated with time on task ($r=.44$, $p<.001$).

Amount of adult involvement. Adults were coded as highly involved in 48 percent of observations, somewhat involved in 26 percent of observations and not involved in 26 percent. Chi-square analyses were carried out to determine differences in distribution of different adult involvement codes according to background variables of participants and to exhibit. These analyses found the following:

1. No gender differences among children in terms of amount of adult involvement;

2. Children in family and school groups were equally likely to be observed with adults coded as highly involved. However, children in family groups were much more likely than children in school groups to be observed with adults coded as somewhat involved, and children in school groups were much more likely than children in family groups to have adults coded as not involved (Chi-square=7.72, d.f.=2,$p<.05$); and

3. Exhibits with a high percentage of highly involved observations were the School Bus Fieldtrip (85 percent) and the TV Studio (83 percent)(Figure 3). Observations at the River were most likely to be coded as somewhat involved, while the City Bus and Pegafoamasaurus had the most coded as Not Involved.

ANOVA analyses found that overall, number of instances of learning is significantly higher in observations coded for Highly Involved than for those coded somewhat involved or not involved ($F=9.61$, d.f.=2, $p<.001$). There is not a significant difference between somewhat involved and not involved overall. There is no significant difference in learning in progress between amount of adult involvement codes. As would be expected, ANOVAs showed number of instances of scaffolding to be significantly higher for observations coded as highly involved than for somewhat involved or not involved ($F=33.943$, d.f.=2, $p<.001$).

DISCUSSION

The study found that learning did occur while children interacted with exhibits at the museum, although some exhibits were associated with more learning than others. Simple cause and effect learning occurred more frequently than other types of learning, and learning was significantly more likely to occur in the presence of scaffolding than without. Further, certain exhibits were associated with more scaffolding than others. While learning was generally correlated with amount of time spent at an exhibit, it was possible for children to spend long amounts of time without learning recorded, and it was also possible for learning to occur when children were only at exhibits briefly. Each of these main points will be elaborated on below.

The most common form of learning observed was what the study called simple cause and effect, involving learning of a physical relationship between two things. Examples of simple cause and effect learning included manipulating switches at the City Bus to turn on lights and make noise, putting balls in and watching them go down the ramps at the Rollaway, and moving knobs to make the ferry go across the River.

The study considered this form of learning to be one of the least compelling found, as it was very simple and usually quite specific to the Please Touch Museum context.

Simple cause and effect can be contrasted with other forms of learning which occurred more rarely but which are more generalizable outside the museum and/or of a higher order nature. One of these more interesting types of learning was information learning which is compelling because it is a clear-cut type of learning that is easily understood by people and may be generalizable beyond the exhibit. It occurred at the City Bus, where children learned what bus drivers ask and tell passengers, as well as at the Grocery and the Kitchen. In these last two areas children learned from adults such things as where to put different items of food away, how to cook fish, and that leaving a package on the stove could cause a fire. Importantly, the contextualized nature of information learning in the museum can be contrasted with information learning in school which is often decontextualized and teacher-initiated. In the museum children tended to learn facts as they carried out or pretended to carry out activities that are important in the community, and the learning was generally child-initiated. An example of this situated information learning as it occurred in the Grocery/kitchen follows:

Child (C) holds up a box of cereal.
C: Want this?
Teacher (T): Yeah, but we need some milk.
C looks in refrigerator, which is open.
T: You gotta close the fridge or your milk'll get hot
C gets milk out and closes fridge

A second noteworthy type of learning was procedural learning, especially as it occurred at the School Bus Fieldtrip exhibit. This type of learning involved children learning to listen to questions posed by the video, making a choice, and pressing the appropriate buttons, and is considered important because it may be generalizable to technological contexts outside the museum, such as interactions with computers. A third important form of learning was conceptual cause and effect learning. This type of learning occurred very rarely, but was seen most often at the Rollaway, where children learned to fix problems in the ramps so that the ball could go down the path without getting stuck or falling out. This type of learning appeared to involve a form of problem solving which has potential applicability outside the museum setting, and which involved higher order learning.

The differences in quality of different kinds of learning is important in assessing the learning potential of different exhibits. The highest amount of learning was recorded at the City Bus, for example, but the large majority of this learning was simple cause and effect (although some script learning also occurred). Of all the exhibits, as can be seen in Tables 5 and 6, the Pegafoamasaurus and the River had the least amounts of learning overall, and most of the learning which occurred at these sites was not of very high quality. Time spent by children at the Pegafoamasaurus was low, supporting expectations that children are more likely to learn when they spend time at an activity. The

Figure 3. Young Please Touch Museum visitors act as TV producers at the TV Studio exhibit. *Photo courtesy of Please Touch Museum.*

Rollaway and School Bus Fieldtrip, however, had more procedural and conceptual cause and effect learning.

In terms of types and frequency of learning, then, the study adds to existing research on learning in hands-on contexts by showing that learning does occur in children's museums when children interact with exhibits as they are. Further, behaviors closely related to learning, such as script expression and asking questions (without receiving a response), also frequently occurred. It is encouraging in that it demonstrates that many kinds of learning are experienced by young visitors throughout the museum. It is cautionary, however, in that it demonstrates that much of the learning is simple cause and effect, and that higher-order learning is not all that common and may be concentrated in a few exhibits.

The study also supports previous research on the importance of scaffolding for child learning. Study findings show that children stayed longer at exhibits and learned more when they were accompanied by an adult who was actively involved in the activity, indicating that adult participation is supportive of learning at children's museums. The study also found that scaffolding was relatively more frequent and/or more intensive at certain exhibits. Analysis of the observation records indicate that exhibits which are conducive to adult scaffolding are activities in which it is clear to adults what they should and can do, and where either the activity is attractive to adults but children have trouble doing it correctly on their own or the activity invites script and not much else. Two exhibits which were attractive to adults but which children had trouble doing on their own were the Rollaway and the School Bus Fieldtrip (Figure 4), hence rates of scaffolding were high during observations at these exhibits. Rates of scaffolding were

Figure 4. A child and his grandmother work together at the School Bus Fieldtrip exhibit. *Photo courtesy of Please Touch Museum.*

also high at the Grocery/kitchen, which invites Script Learning. The finding that some contexts are more conducive to adult participation than others supports previous research (cf., Borun et al. 1997; Borun and Dritsas 1997; Gelman et al. 1991) and indicates that to maximize learning and child engagement at exhibits designers may need to attend to the issue of adults' reactions to exhibits as well as the children's.

In terms of amount of adult involvement, it is interesting to note that while significant differences were found between the learning of children with a highly involved adult and children with adults somewhat involved or not involved, no differences were found between children with adults in the somewhat involved and not involved categories. This indicates that in order to influence children's learning, adults must be actively involved verbally and/or physically in the exhibit activity with the child. In terms of learning, simple physical presence and provision of an occasional exhibit-related remark are similar in effect to not being there at all. School groups visiting the museum tended to have lower adult-to-child ratios than family groups. Since adult scaffolding was important for learning in the study, one would be tempted to assume that children in family groups would learn more. Interestingly, however, children in school groups were as likely as children in family groups to have an adult highly involved at the exhibit. They were less likely to have an adult somewhat involved, but since study results indicate that only highly involved adults had an impact on learning, children in school groups may be just as likely to learn from the children's museum as children in family groups.

The study also distinguishes between child engagement and learning, by showing that engagement, (as measured by amount of time spent at an exhibit), can occur in the absence of much observable learning, (as illustrated in particular by some children's interactions with the River exhibit) and that high quality learning can occur in relatively short periods of time under the right conditions. Thus studies which evaluate exhibits need to distinguish between engagement in general and learning in particular. On the other hand, study findings also indicate that spending time at an exhibit does make it more likely that learning will occur, independent of scaffolding effects. Thus while keeping children at exhibits longer will not guarantee learning, it seems to increase its likelihood. Finding out more about which kinds of contexts support learning with and without scaffolding and what needs to be present at an exhibit to induce learning with short- or long-term spurts of engagement should be the object of further study.

Most prior studies of learning in hands-on museums have taken place in science museums and involved upper elementary and high school children or adults. Very few published studies of learning in *children's* museums have taken place at all, despite the fact that one of the major goals of such museums is to provide a learning experience for the child. This study provides concrete, naturalistic evidence of important forms of learning in children's museums, as well as evidence of how to maximize learning during a child's visit. Such findings may not only be of use to museums but also may be generalizable to other informal learning activities as they occur in daycare and other settings.

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