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Abstract	Children have many opportunities to learn about science before they start studying science in school. From an early age, children engage in deep conversation with parents and build their own theories for understanding how the world works (e.g., Callanan & Jipson, 2001; Callanan & Oakes, 1992). As children grow, they frequently have opportunities to visit zoos, botanical gardens, parks, science centers, and museums with their parents. According to Resnick (1987), learning in these informal settings depends on more than the individual cognition, pure thought, and symbol manipulation. Informal settings highlight more socio-cultural processes such as shared cognition, tool manipulation, contextualized reasoning, and situation-specific competencies (Schauble, Beane, Coates, Martin, & Sterling, 1996). Families in informal settings engage continuously in a negotiation about who is directing the activity, what the activity is about, and what content there is to be learned (Falk & Dierking, 2001; Swartz & Crowley, 2004). In this chapter we present a study about the impact that different learning goals have upon the ways families interact and what children may learn from an informal learning environment	
Keywords (separated by '-')	Museum learning - family conversations - informal science education - scientific reasoning - developmental psychology	

Chapter 5
Negotiating the Goal of Museum Inquiry: How Families Engineer and Experiment

Kyung Youn Kim and Kevin Crowley

Children have many opportunities to learn about science before they start studying science in school. From an early age, children engage in deep conversation with parents and build their own theories for understanding how the world works (e.g., Callanan & Jipson, 2001; Callanan & Oakes, 1992). As children grow, they frequently have opportunities to visit zoos, botanical gardens, parks, science centers, and museums with their parents. According to Resnick (1987), learning in these informal settings depends on more than the individual cognition, pure thought, and symbol manipulation. Informal settings highlight more socio-cultural processes such as shared cognition, tool manipulation, contextualized reasoning, and situation-specific competencies (Schauble, Beane, Coates, Martin, & Sterling, 1996). Families in informal settings engage continuously in a negotiation about who is directing the activity, what the activity is about, and what content there is to be learned (Falk & Dierking, 2001; Swartz & Crowley, 2004). In this chapter we present a study about the impact that different learning goals have upon the ways families interact and what children may learn from an informal learning environment.

Children have sometimes been described as natural *scientists* in that they construct theories about the world in ways that evoke the history of science (Carey, 1986; Gruber, 1973). However, the ways children construct theories are clearly not the same as scientists (e.g., Kuhn, 1989). In particular, Kuhn has described children as having trouble coordinating theory and evidence (e.g., Kuhn, Amsel, & O'Loughlin, 1988; Kuhn, Garcia-Mila, Zohar, & Andersen, 1995). Children are sometimes described as "data-bounded investigators" who fail to organize evidence into a theory, focusing instead on explaining local patterns of isolated results. They are sometimes described as "theory-bounded investigators" who are likely to adjust evidence to fit their theories and generate positive outcomes rather than seeking negative evidence to disprove a theory (DeLoache, Miller, & Peierroutsakes, 1998). In light of their difficulties in coordinating theory and evidence, how do children come to develop scientific thinking skills? The extant developmental literature does

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a good job providing snapshots of what children can do by themselves, but it has less to say about how they develop and how they actually reason in real-world and social settings.

In this chapter, we explore one setting where children and parents can practice early scientific thinking skills – an interactive science exhibit at a children's museum. Several studies have suggested that enriched informal learning experiences can improve children's inquiry skills (e.g., Gerber, Cavallo, & Marek, 2001; Tamir, 1990; Zuzovsky & Tamir, 1989). For example, Zuzovsky et al. (1989) showed that while knowledge of science facts and concepts was more likely to be predicted by variables such as school environment and teacher interaction, inquiry skills were more likely to be predicted by out-of-school variables such as enriched informal learning experiences, parent's educational level, and availability of books at home. Gerber et al. (2001) also showed that students who had inquiry-based classroom experiences and enriched informal learning experiences were more likely to show higher scientific reasoning abilities. Activity in such informal learning contexts may be a source for children's later motivation and success in formal science education (Crowley & Galco, 2001).

One feature of museum activity is that it is often a social learning context, particularly for young children (Matusov & Rogoff, 1995). Several studies have described how parents shaped and supported children's scientific thinking through talk and joint activity in museums (e.g., Crowley & Callanan, 1998; Crowley et al., 2001; Eberbach & Crowley, 2005). These studies suggested that one role parents often play is to help children generate more informative evidence and to encode evidence in ways that are consistent with the adult interpretation of an exhibit. Gleason and Schauble (2000) showed that greater levels of parent participation during an experimental design task was associated with support for developing better experiments that would then allow children to make more powerful inferences.

This chapter describes an experiment that explored two strategies for supporting parent participation during shared scientific thinking in a museum. We focus on suggesting different goals for the parent–child activity: one goal is for the family to think as scientists and one goal is for the family to think as engineers. This manipulation came out of the scientific reasoning literature, which suggests that children sometimes adopt one goal and sometimes the other (oftentimes vacillating between them in a single task). Prior studies demonstrated that children's choice of goals for a scientific reasoning task not only influences their inquiry process but also affects what they learn (e.g., Schauble, 1990; Schauble, Klopfer, & Raghavan, 1991; Tschirgi, 1980). When children adopt an engineering goal, they seek to produce a desired outcome rather than to test their theories (e.g., Kuhn & Phelps, 1982; Schauble, 1990; Schauble, Glaser, Duschl, Schulze, & John, 1995; Tschirgi, 1980). Children often seek to compare highly contrastive combinations of variables and focus on variables believed to be causal. In contrast, when children adopt scientific goals, they are more likely to explore evidence widely and to make comparisons that support valid inferences that lead to better theory building (Schauble et al., 1991).

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In this study we explored the role of science vs. engineering goals in the context of parent–child interactions. Families in the study used a design task that was built around a museum exhibit. One group of families used the exhibit with science goals and a second group used the exhibit with engineering goals. By analyzing videotapes of the parent–child interactions and child performance on a knowledge pretest and posttest, we explore the effects of different reasoning goals on what children learn from the design task, the ways families engage in the task, and the ways parents support children's scientific thinking in real-world settings.

Method

Participants

Participants were 30 families with children between 5 and 8 years old who stopped at the flying machine exhibit while visiting the Children's Museum of Pittsburgh. Families were randomly assigned to either the science condition (seven boys and eight girls) or the engineering condition (eight boys and seven girls).

Materials

The Rotocopter Task

The experimental task we developed involved families dropping rotocopters from a two-story tower inside the Children's Museum of Pittsburgh. Visitors were presented with 12 rotocopters made of paper. Visitors could choose one or more rotocopters, crank them to the top of the tower, and then observe the outcomes as the rotocopters floated down to the floor.

As shown in Fig. 5.1, the 12 rotocopters we designed for this experiment varied by a factorial combination of three variables: wing shape; weight; and color. First, wing shapes differed in length and surface area. Although the rectangle wing had the same wing length as the diamond wing, its surface area was two times larger. The diamond wing had the same surface area as the square wing, but its wing was longer. The second causal variable was weight. Rotocopters with one paper clip were categorized as "light" and those with two paper clips as "heavy." Finally, we included color as a noncausal variable.

As shown in Fig. 5.1, the rotocopter flight times varied according to wing shape and weight. The rectangle wing flew longest because it had longer wings and the largest surface area. In contrast, the square wing flew shortest because it had shorter wings and the smallest surface area. The light rotocopter with one paper clip flew longer than the heavy one with two paper clips. Therefore, the light paper rotocopter with the rectangle wing showed the longest flying time and the heavy one with a square wing showed the shortest flying time.

In order to manipulate two inquiry goals for this task, we developed two signs for the exhibit that focused either on science or on engineering goals (see Fig. 5.2). Each

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a. Rotocopter examples

b. Three variables combined in the rotocopter task

Weight	Heavy		Light	
Color / Shape	Blue	Pink	Blue	Pink
Rectangle wing				
Diamond wing				
Square wing				

c. Mean (and Standard Deviation) for rotocopter drop times over 10 trials

	Rectangle	Diamond	Square
Light	4.5 (.03)	3.1 (.04)	2.7 (.04)
Heavy	4.1 (.04)	2.9 (.04)	2.5 (.03)

Fig. 5.1 a. Rotocopters provided to the participants. b. Three variables are combined in the rotocopter task: wing shape (rectangle/diamond/square); weight (heavy/light); and color (blue/pink). Wing shape and weight are causally related to flight time. Color is not. Wing shape involves both wing length and the surface area, but the weight of the paper is constant. Without changing the overall weight of each rotocopter, different wing shapes are made by folding the rectangle wings in different ways. Weight is manipulated by attaching one or two paper clips to each rotocopter. c. In order to examine the effect of two causal variables (wing shape and weight) on drop time, we timed 10 drops for the six unique rotocopters (3 wing shape $\times$ 2 weight) from a height of two stories. Step-wise multiple regression suggested that wing shape accounted for 87% of the variance in flying times, $F\,(1, 58) = 408.98$, $p < 0.001$. Weight accounted for an additional 3% of the variance, $F\,(2, 57) = 278.78$, $p < 0.001$, resulting in a final regression equation of flight time = 1.31 + 0.81 (wing shape) + 0.25 (weight)

sign was approximately 3 $\times$ 4 ft and was placed prominently next to the exhibit. The science sign focused families on the idea that their goal was to figure out the effects of different variables while the engineering sign concentrated on the goal of maximizing the effect of the variables.

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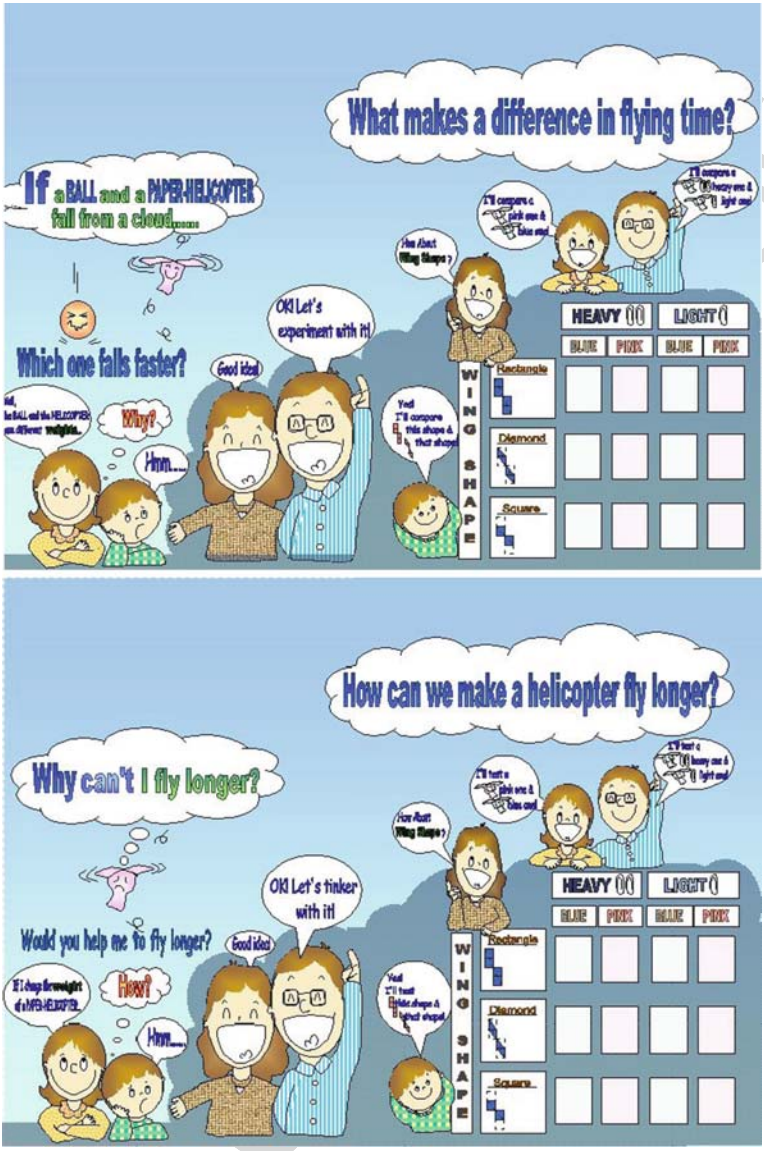

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Fig. 5.2 Signs that encouraged families to adopt science or engineering goals. The science sign (top) focused families on exploring the effect of each variable to figure out how the system works. The engineering sign (bottom) encouraged families to approach the task in terms of looking for the rotocopter that could "win" by flying the longest time

Procedure

After setting up video cameras and wireless microphones at a location near the exhibit, a researcher approached families and asked whether they were interested in participating. If families indicated interest, the researcher obtained informed written consent.

First, children were given a pretest designed to assess their understanding of the causal role of wing shape and weight, and the noncausal role of color. Parents sat off to one side as children were shown three sets of rotocopters and asked to order the rotocopters in terms of relative drop speeds. One set of three rotocopters varied by wing shape (rectangle, diamond, square) while holding weight and color constant. One set of two rotocopters varied by weight (heavy, light) while holding wing shape and color constant. One set of two rotocopters varied by color (pink, blue) while holding wing shape and weight constant. Order of presentation was randomized.

After the pretest, families were asked to read the sign together. The intent of the sign was then verbally reinforced by the experimenter who talked families through the information on the sign. Families were then asked to use the exhibit for as long as they wanted and were asked to tell the experimenter when they were done. Family interactions were videotaped.

At the conclusion of the activity, children completed a posttest while their parents sat off again to one side. The posttest differed from the pretest in that, in addition to getting the same judgments as in the pretest, on the posttest we also collected children's justifications for their reasoning at two points. Children were asked first to talk about why the rotocopters have different drop times. Children were then asked, just as in the pretest, to order the rotocopters by drop time. We then asked children to explain the way they ordered the rotocopters.

All videos were transcribed for both action and talk, and coding was conducted with both video and transcripts. We introduce our coding schemes and measurement construction at appropriate times in the results section below. Coding was conducted by single coder. Reliability was assessed by an independent coder who scored 25% of the data. Reliability exceeded 84% for all coding reported in this chapter.

Results

Children in the Science Condition Learned More About the Causal Variables. The primary measure of children's learning was pretest to posttest changes on the three sets of rotocopters that children ordered in terms of flight time. For each set of rotocopters, we assigned scores that ranged from 0 to 2. For the set of three where wing shape varied, children were assigned a 0 if they said that all three would fall at the same time; a 1 if they said that they would fall at different times but did not order correctly within the set; a 1.5 if they ordered two but not three correctly; and a 2 if they ordered all three correctly. For the set of two where weight varied, children were assigned a 0 if they said both would fall at the same time; a 1 if they said they would fall differently but did not order correctly; and a 2 if they indicated the correct order. For the set of two where color varied, children were assigned a 0 if they indicated that the rotocopters would fall at different speeds and a 2 if they indicated that they would fall at the same speed. Adding these scores together,

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children could have a pretest or posttest score of 0–6. Gain scores were computed by subtracting pretest from posttest scores; thus, gain scores could range from −6 to 6.

Overall, children in the science condition had significantly higher gain scores (M=1.2) than children in the engineering condition (M= −0.5), $t\ (28) = 2.71$, $p < 0.05$. When we divided the overall scores into gain scores for each of three variables separately, children in the science condition showed higher gains for shape (Ms=0.3 and −0.1, respectively), weight (Ms=0.5 and −0.5), and color (Ms=0.4 & 0), although only the difference for weight was significant, $t\ (28) = 2.49$, $p < 0.05$.

In addition to ordering the rotocopters by drop time, children had also been asked on the posttest to justify their choices. We assigned children a point each time they mentioned relevant variables. That is, children had to mention specific rotocopter features such as wing length or size (e.g., longer vs. shorter or bigger vs. smaller) to get a point for wing shape. For weight, they had to refer to difference in weight (e.g., heavier vs. lighter or more weight vs. less weight) beyond pointing out the number of paper clips. For color, children had to indicate that both rotocopters performed the same regardless of color. Findings were analyzed using one-way ANCOVAs with children's posttest justifications as the dependent measure and their pretest choice score as a covariate.

The justifications provide converging evidence that children in the science condition learned more than children in the engineering condition. In response to the open-ended question that was at the beginning of the posttest, children in the science condition (M=0.9) were more likely to name causal variables than children in the engineering condition (M=0.5), $F\ (1, 27) = 5.96$, $p < 0.05$. A similar pattern emerged when we examined the justification data for children's wing-shape choices, with children in the science condition (M=0.6) being more likely to be able to offer good explanations for their choices than those in the engineering condition (M=0.2), $F\ (1, 27) = 5.42$, $p < 0.05$. There were no differences, however, in children's justification for weight (Ms=0.3 and 0.3, respectively) or color (M= 0.8 and 0.5).

Families in the Science Condition Were More Systematic and Engaged. Families in the science condition (M=7 min 38 s) spent significantly more time testing rotocopters than those in the engineering condition (M=4 min 59 s), $t\ (28) = 2.21$, $p < 0.05$. Although spending almost 34% more time on task, families in the science condition did not conduct significantly more trials (M=5.9) than those in the engineering condition (M=4.8), suggesting that families in the science condition spent more time conducting each of their trials.

How many of these trials were controlled comparisons that could support valid inferences about the causal status of a variable? Families in the science condition (M=1.9) were more likely to conduct controlled comparisons than those in the engineering condition (M=0.8). The difference was not significant, mostly due to one family in the engineering condition who conducted seven controlled comparisons in their eight trials, which amounted to more than three standard deviations above the mean for the engineering condition. When we excluded this family's data, the mean for the engineering condition dropped to 0.4 and the group difference was significant, $t\ (27) = 2.79$, $p < 0.05$. Another way to examine these data is to ask how many families used a controlled comparison strategy at least once: more families in

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the science condition (10) did so than families in the engineering condition (4), *æ*^{2} (1) = 4.82, $p < 0.05$.

Differences in Family Activity Appeared Mostly in the Design and Interpretation of Tests. One of the reasons we chose the flying machines exhibit for this study was that the physical space around the exhibit mapped on to the conceptual space of an inquiry cycle. As shown in Fig. 5.3, families would design tests by going to one place to choose rotocopters, run their test by putting rotocopters on the platform and cranking them over the tower, and interpret their tests by running out in front of the tower to observe the relative drop times. In the final section of the results, we describe how families engaged in each of these three stages.

First, we examined how much parents and children talked to each other while cycling through each of the three inquiry stages. In general, children did not do much talking in any of the spaces. We observed only about one utterance per trial for children irrespective of whether they were working in the design space (M=1.1 and 0.8 for science and engineering conditions, respectively), test space (M=0.9 and 1.3), or interpretation space (M=1.1 and 0.8).

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Most of the talk we observed was by parents. And parents in the science condition were often more likely to talk than those in the engineering condition. In the design space, parents in the science condition (M=3.3) spoke significantly more often than those in the engineering condition (M=1.8), t (28)=2.07, $p < 0.05$. The same was true in the interpretation space, where science parents were observed making a mean of 2.7 utterances per trial vs. 1.5 for the engineering parents. In the test space, where most of the parent talk was around encouraging children to keep cranking the handle until the rotocopters launched from the top, science parents also were observed to talk more often than engineering parents (M=3.7 vs. 2.5), but the difference did not prove significant.

Finally, we conducted qualitative coding of the family interaction patterns and talk in each of the design, testing, and interpretation spaces. In coding interactions, we considered two dimensions of parent–child activity: (1) the extent to which parents provided explanatory support and (2) the extent to which parents and children collaborated. We rated each interaction as high or low on the two dimensions, producing four separate categories of inquiry:

1. *Shared and Supported*: Parents were observed to provide talk that directly supported inferencing and were observed to respond to children's comments or choices. Children were observed to actively respond to parent input and to collaborate with parents in using the exhibit. The definition of this category was specific to each of the three spaces. In the design space, parents had to make comparisons of levels of a variable (e.g., "Do you want to see if the different wings make a difference?" "Why don't we try a pink one and blue one, each with two paperclips?" "Do you want to see a diamond make any difference?" or "Look this has square wings! This one has different kinds of wings"). In the test space, parents had to talk about predictions (e.g., "Do you think it makes a difference?" or "Which one do you think will stay up longer?"). In the interpretation

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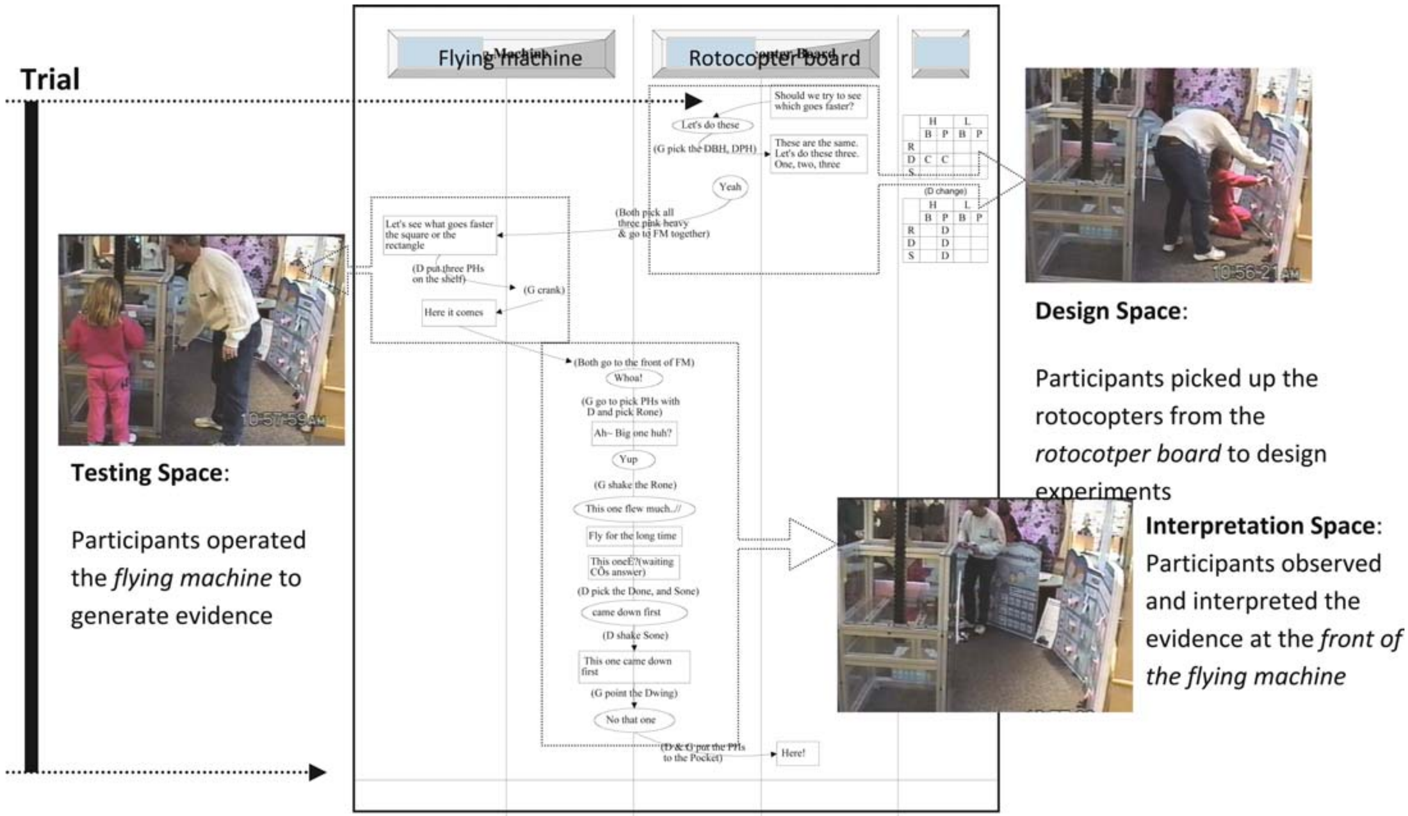

Fig. 5.3 Parent–child talk and action were transcribed with respect to three activity spaces: the design space (where rotocopters were chosen), the test space (where they were cranked up), and the interpretation space (where they landed). On the first column from the right, we recorded which rotocopter(s) was/were chosen at each trial. On the second and third columns from the right, we transcribed parent–child talk and action at the design space. On the first and second columns from the left, parent–child talk and action at the test space were transcribed. On the center line, parent–child talk and action at the interpretation space were recorded. The rectangular boxes represent parent's talk and ellipses represent child's talk

space, parents had to talk about the outcome by comparing different rotocopters (e.g., “This one stayed in the air the longest,” “I think that one went even faster,” or “This one came down first.”)

2. *One-way supported:* This was coded if parents generally engaged in inquiry-specific talk as defined above, but children were not collaboratively engaged. Either the parent was directing the interaction without input from the child or the child was engaged without reference to the parent’s talk.
3. *Shared but unsupported inquiry*: Parent and child were observed to be collaborative, but parents were not engaged in providing inquiry-specific support through talk. To be coded in this category, parent support could not go beyond general suggestions (e.g., Why don’t you try different one?), verbal directions (e.g., “Pick one out,” “Pick a different one,” “Put one over here,” or “Stand back and watch them”), or simple encouragement (e.g., “You did it,” or “Keep going! Keep going!”).
4. *Neither shared nor supported inquiry*: Parents were not observed to support children’s inquiry directly and parents and children were not engaged collaboratively in the activity. These were the interactions where children worked more or less alone while parents stood back and watched.

The findings, shown separately for each of the three spaces, are in Table 5.1. First consider the findings while families were designing comparisons. In the science condition, 39% of family activity was coded as *shared and supported inquiry*,

Table 5.1 Mean number of trails coded as each kind of engagement broken down by condition

Activity space	Type of parent–child engagement	Science families	Engineering families	*t*	*p*
Design	Shared and supported	2.27 (39%)	0.67 (14%)	2.66	<0.05
	One-way and supported	1.40 (24%)	0.87 (18%)	1.00	NS
	Shared and unsupported	0.60 (10%)	0.47 (10%)	0.57	NS
	Neither shared nor supported	1.60 (27%)	2.80 (58%)	−1.57	NS
Test	Shared scientific engagement	1.53 (26%)	0.60 (13%)	1.32	NS
	Scientific engagement directed either by parent or by child	0	0.07 (1%)	−1.00	NS
	Nonscientific but shared engagement	3.40 (58%)	2.60 (54%)	1.17	NS
	Neither scientific nor shared engagement	0.93 (16%)	1.53 (32%)	−1.20	NS
Interpretation	Shared scientific engagement	2.73 (47%)	1.00 (21%)	2.83	<0.01
	Scientific engagement directed either by parent or by child	1.00 (17%)	0.73 (15%)	0.78	NS
	Nonscientific but shared engagement	0.87 (15%)	0.60 (13%)	−1.56	NS
	Neither scientific nor shared engagement	1.27 (22%)	2.47 (51%)	0.93	NS

The percentage the mean represents in the total number of trials in each condition is included in parentheses

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compared with only 14% in the engineering condition, t (28)= 2.66, $p < 0.05$. In the engineering condition, 58% of parent–child engagement was coded as *neither shared nor supported*. That is, parents in the science condition were more likely to collaborate with children by describing the rotocopters children picked or by suggesting ideas for designing informative experiments. Children in the science condition were also actively engaging in the negotiating process for choosing rotocopters through responding to parent's questions or suggestions. Parents in the engineering condition were less likely to collaborate with children in designing experiments and often left children to pick out rotocopters alone.

In the test space, no difference was found in any of the parent–child engagement codes. Out of the four parent–child engagement patterns, the *shared but unsupported inquiry* was the most frequently coded in both the science condition (58%) and the engineering condition (54%). In both conditions, parents provided similar amount of domain-related support to children in a collaborative way.

In the interpretation space, 47% of parent–children engagement in the science condition was coded as *shared and supported inquiry*, compared with only 21% in the engineering condition, t (28)= 2.83, $p < 0.01$. The most common code in the engineering condition was *neither shared nor supported inquiry*. Parents in the science condition were most likely to collaborate with their child as they evaluated evidence by comparing the flying times of more than two rotocotpers, whereas parents in the engineering condition were more likely to leave children to interpret the outcome by themselves.

Discussion

This study examined how different inquiry goals affected joint exploration, parent participation, and subsequent child learning. At the simplest level, we found that signage and simple instructions were sufficient to change the nature of family inquiry at an interactive science exhibit. When families were encouraged to adopt science goals for inquiry, they talked more to each other, they were more collaborative, and they were more likely to design informative tests. Families who were encouraged to adopt engineering goals were more likely to have parents who pulled back and allowed children to do more of the design and interpretation without adult scaffolding. As one might expect from these differences in family inquiry, we also discovered differences in what children had learned by the end of the session. Children whose families had adopted science goals learned more about the task than children whose families adopted engineering goals.

Our findings suggest that differences in parent talk were most prominent at the design and interpretation phases of inquiry, which are identified as the critical processes for scientific thinking in the scientific reasoning literature (Klahr, 2000; Klahr & Dunbar, 1988). While choosing rotocopters in the design space, parents in the science condition scaffolded children's choice of rotocopters more carefully by

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describing the specific features of rotocopters, soliciting children's ideas, or suggesting their own ideas about what they wanted to try for figuring out the effects of the embodied variables. In the interpretation space, parents in the science condition were more likely to support children's understanding of the effect of variables by comparing different drop times of different rotocopters, asking children about what they see and what they found out, or discussing which features of the fallen rotocopters were related to their findings.

The following examples illustrate different patterns of family engagement in the science and engineering condition. Our intention in presenting these short examples is to provide the reader with some sense of what the quantitative findings look and sound like when families are engaged in reasoning. We begin with the engineering condition. We often observed children in the engineering condition moving about choosing rotocopters to design a test and then going to pick up the fallen rotocopters while their parents stayed more stationary and provided encouragement but relatively little scaffolding for the experimental activity. Consider the following trial from a family with a 6-year-old girl in the engineering condition:

Design space
Father: Do you want to fly? Go ahead and fly.
[Child goes to the rotocopter board alone and picks up the pink-light-square rotocopter and blue-light-rectangle rotocopter]
Test space
Father: Oh. . .oh..oh. . .you can do one at a time.
[Child puts two rotocotpers one by one on different platforms and goes to the front of the flying machine to watch]
Father: Come here, [name]. Go ahead! Turn!
[Child comes back to the flying machine and cranks]
Get ready!
Interpretation space
Father: All right!
[Father and child watch how pink-light-square rotocopter flies at the flying machine]

In contrast to families in the engineering condition, those in the science condition were more likely to collaboratively explore all the variables, with parents showing more involvement, especially in design and interpretation. The following is a 6-year-old girl with father:

Design space
Father: Which one do you want to start with?
Child: This one [picks up the blue-light-rectangle wing].
Father: All right! Do you want to do a couple different ones?

The square one [picks up the blue-light-square rotocopter], the diamond one [points to the blue-light-diamond and child picks it up], and this one [points the rotocopter that child already has]. We can put them all on there and see which one lands first.

Child: OK

[Both move to FM together]

Test space

Father: Crank this, this way.

[Child starts to crank]

Father: Do you need help?

And watch comes down then.

Child: Keep going! You're almost there! Almost there!

Interpretation space

Father: Oh, Look! Which one was first?

[Both move to the front of the flying machine]

Child: Uhh... this one [picks up the blue-light-square rotocopter].

Father: Well it was close, which one land the last?

Child: This one [picks up the blue-light-rectangle rotocoper and gives it to father].

The contrast between these examples is clear. The first father appeared to have interpreted the engineering goal as a suggestion that he withdraw from the interaction and allow his daughter to find the best combination of variables. In the second example, the father appeared to interpret the science goal as an opportunity to become more involved, and to scaffold design and interpretation. Why did parents make these choices? Our data do not directly address this question but we can make some guesses. It is possible, for example, that parents saw the goal of finding the longest flying rotocopter as a fairly straightforward search problem that would not require their participation. Children, even if they searched blindly, would eventually stumble onto the correct solution. However, in the science condition, parents may have interpreted the science goals as more challenging for their children. Making inferences about the causal roles of variables may be a task that invites talk and collaboration.

Our finding that signage can influence family activity and child learning has implications for the design of museums and other informal learning environments. Others have observed that museum exhibitions and programs often are not well-designed to facilitate family's shared meaning-making and collaborative learning (e.g., Falk & Dierking, 2001; Schauble et al., 2002). Further research has focused on ways that families can mediate their museum experiences through talk (e.g., Ash, 2003, 2004; Borun, Chambers, & Cleghorn, 1996; Borun, Cleghorn, & Garfield, 1995; Leinhardt, Crowley, & Knutson, 2002) and the important role of parents as the family members who often share symbolic information gained from reading labels or from prior experience, while children do most of the touching and manipulating

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hands-on exhibits (e.g., Crowley et al., 2001; Diamond, 1980, 1986; Rahm, 2002). However, it is not always easy for parents to figure out what roles they might adopt in informal learning settings and the impact those roles might have on their children's experience (Gleason & Schauble, 2000; Schauble et al., 2002; Swartz & Crowley, 2004). The present findings suggest that signage is a support that can help parents adopt goals and define roles for themselves in museums. The findings further suggest that signage that supports science goals as opposed to engineering goals may result in greater collaboration and more structured inquiry as families engage in informal science activity in everyday settings such as museums.

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Chapter 5

Q. No.	Query
AQ1	"Zuzovsky et al. (1989)" is not listed in the reference list. Please provide.
AQ2	Please check whether the edit made to the sentence " We observed only about one ..." is correct.
AQ3	"Ash, 2003, 2004" is not listed in the reference list. Please provide.
AQ4	"Diamond, 1980" is not listed in the reference list. Please provide.

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