Museum Visitor Studies, Evaluation & Audience Research

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Summative Evaluation of the *Skyline* Exhibition

Prepared for the
Chicago Children's Museum
Chicago, IL

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INTRODUCTION

This report presents the findings from a summative evaluation of the National Science Foundation-funded *Skyline* exhibition conducted by Randi Korn & Associates, Inc. (RK&A) for Chicago Children's Museum (CCM). RK&A conducted visitor observations and interviews to examine the extent to which the exhibition achieved its intended impacts. Further, RK&A compared observation data from this summative evaluation with baseline data from a 2004 front-end evaluation of *Skyline* collected in CCM's previous building exhibition, *Under Construction*. The summary below highlights key findings that address the exhibition's intended impacts as well as visitors' overall exhibition experiences.

Selected highlights of the study are included in this summary.
Please consult the body of the report for a detailed account of the findings.

PRINCIPAL FINDINGS: OBSERVATIONS

Observation data for the summative evaluation of the *Skyline* exhibition were collected in July 2008 at CCM. Data collectors trained by RK&A observed a total of 100 children in the target age range of 4 to 10 years old. Of the child visitors observed, 52 percent were female and 48 percent were male.

WHOLE EXHIBITION

- Two-thirds of observed groups were first-time CCM visitors and one-third were repeat visitors (67 percent and 33 percent, respectively); of repeat visitors, two-thirds were visiting *Skyline* for the first time (68 percent).
- Observed children's total time in *Skyline* ranged from about 5 minutes to more than 1 hour. Median time in the exhibition was 22 minutes and 38 seconds.

LARGE-SCALE BUILDING AREA

- During most of the observations in the large-scale building area there were many existing structures; whereas in *Under Construction* there tended to be fewer structures.
- The large-scale building area attracted more girls than boys as compared with *Under Construction* (57 percent and 37 percent, respectively).
- Children in the large-scale building area spent more time building than did those in *Under Construction*—nearly three times as long (a median time of 22 minutes and 34 seconds versus 8 minutes and 54 seconds).
- 71 percent of observed children built with materials one or more times; no statistically significant differences were found in the building behaviors of male and female children.
- Children in the large-scale building area were more likely to create structures that stood (40 percent) compared to children in *Under Construction* (11 percent).

- Children in the large-scale building area were more likely to work with their accompanying adults (73 percent) than were children in *Under Construction* (51 percent).[1]
- A majority (84 percent) of children had building strategies or tool-use modeled for them by their caregivers.
- Slightly more than one-third (40 percent) of the observed children worked collaboratively with their adult caregivers (i.e., worked together equally or the adult followed the child's lead at least 75 percent of the time).
- More than one-half of observed children were coached during building or had building modeled for them by adults (66 percent and 54 percent, respectively); no statistically significant differences were found in adults' coaching behavior of male and female children.

PHOTO-NARRATIVE EXPERIENCE

- During nearly all of the observations in the photo-narrative experience (98 percent), there were many existing structures.
- A total of 49 visitors were observed building, for a median of 15 minutes and 25 seconds.
- Nearly all observed children built with materials one or more times (94 percent).
- Nearly all observed children built with the adult(s) in their group (96 percent).
- More than three-quarters also coached and modeled how to build one or more times (83 percent and 79 percent, respectively).
- In 48 percent of the observations, the observed child and adult(s) worked collaboratively (i.e., worked together equally or the adult followed the child's lead at least 75 percent of the time).
- About three-quarters of observed children and/or their companions created structures that stood (72 percent).
- Nearly all observed children did the narrative activity with the adult(s) in their group (87 percent); about three-quarters also coached the observed child on how to do the narrative activity (72 percent).

PRINCIPAL FINDINGS: IN-DEPTH CHILD INTERVIEWS

RK&A conducted 50 onsite interviews with visitors 5 to 10 years old visiting with family groups as they completed their building experience in the *Skyline* exhibition in July and August 2008.

OVERALL EXPERIENCE

- Most interviewees spoke positively about their exhibition experience and about one-half of interviewees said there was nothing they did not like about the exhibition activity.
- When asked their motivation for visiting *Skyline*, about one-half of interviewees said they participated because they wanted to build something.
- Nearly all visitors collaborated with someone within or outside their visiting group to build their structure.

[1] Worked with their accompanying adult is defined as an observed child working with the adult in their visiting group one or more times during the observation period.

USE OF STEM-BASED LANGUAGE AND CONCEPTS

- When asked what they did to make their structure stand up, slightly more than one-half of interviewees used STEM-based language and concepts (see Appendix H) when describing their structure.
- When asked how they knew how to make their structure stand without falling over, about one-third of interviewees said a parent or other adult told them what to use or they copied the ideas they observed in other structures.

PRINCIPAL FINDINGS: IN-DEPTH ADULT INTERVIEWS

RK&A conducted 50 onsite adult interviews with visitors 18 years and older visiting with family groups and at least one child aged 5 to 10 as they completed their building experience in the *Skyline* exhibition in July and August 2008.

OVERALL EXPERIENCE

- Nearly three-quarters of interviewees described their experience with extreme enthusiasm and excitement—a few saying it was one of the best children's exhibitions they had ever used and a few others saying they repeatedly visit the exhibition.
- When asked to explain what they liked so much about the exhibition, about three-quarters of interviewees described their affinity for the exhibition in terms of how it promotes creativity, independence, free play, and imagination.
- One-quarter of interviewees enjoyed the exhibition, but were less enthusiastic than the group described above. Notably, some of the less enthusiastic interviewees did not participate in the activity with their children.
- One-half of interviewees said there was nothing they liked least about the exhibition and about one-half said their only complaint was looking for, and sometimes not finding the materials and resources they needed to build their structure.

GROUP COLLABORATION

- More than three-quarters of adult interviewees said they worked with their children to build a structure and of these, nearly all found the experience extremely satisfying.
- Interviewees who worked with their child were asked to identify the most difficult aspect of group work; most said it was teamwork. Notably, none of these interviewees complained about teamwork, but rather described its challenges.

BUILDING THE STRUCTURE

- When asked how they figured out how to build their structure, one-third said they used "trial and error" and another one-third said they used previous knowledge.

UNDERSTANDING OF STEM-BASED CONCEPTS

- When describing what they did to stabilize their structure so that it would stand without falling over, about three-quarters of interviewees used STEM-based language and concepts (see Appendix H) and most of these said they used diagonals or triangles.

- Not all interviewees mentioned the use of triangles unprompted, but when asked specifically if they had used triangles and what they had used them for, more than one-half said they used triangles to stabilize their structure.
- Adults who said they had not worked with their child to build the structure were the ones most likely to respond to questions about stabilizing their structure by saying they did not know or by commenting generally. They were also more likely to say their child had *not* used a triangle to stabilize his/her structure.

EXHIBITION INFLUENCE

- One-quarter of interviewees said the organization and simplicity of the exhibition's design had helped them build their structure (e.g., all the materials were easy to use and identify).
- One-quarter of interviewees who worked on their structure with their child said nothing about the exhibition had helped them or that they did not know whether anything had.
- Several interviewees said that other visitors' structures provided examples that they could model and several said the information about triangles had helped them.

PRINCIPAL FINDINGS: PHOTO-NARRATIVE EXPERIENCE

In July and August 2008, RK&A intercepted visitors 18 years and older visiting with family groups and at least one child between the ages of 5 to 10 as they completed their photo-narrative experience in the *Skyscraper Challenge* exhibit of the *Skyline* exhibition. The photo-narrative experience consists of visitor groups audio recording their responses to six questions about their building experience (see Appendix F for the questions used).

VISITORS' AWARENESS OF BUILDING PROCESS

- When asked how they figured out how to start building, one-third of visitors described using trial and error and teamwork to plan and one-third said they chose to start their structure with a foundation and built "up" from there, sometimes specifying that they added walls or support bracing.
- When asked what they were thinking as they built their structure, many visitors said they were thinking about how to build their structure taller, more quickly, or more stable.

PROBLEM-SOLVING STRATEGIES

- When asked what problems they had as they built, about one-third of visitors said they had difficulty choosing which pieces to use and how to use them; one-third said they had trouble stabilizing their building; and, one-third said they did not have enough pieces to work with or enough time to complete their structure.
- When asked how their team tried to solve their building problems, slightly more than one-half of visitors said they used teamwork and brainstormed how to fasten things together.

VISITOR LEARNING

- When asked what they learned or would remember from making their building, slightly more than one-half of visitors said they learned or would remember that teamwork is necessary for building, that communicating with your team can be difficult, or that working with others to build something is fun.

- About one-third of visitors said they learned or would remember how to attach nuts and bolts together or that one must make a building stable.

STEM-BASED LANGUAGE AND CONCEPTS

- Slightly more than one-half of visitor groups used STEM-based language or concepts (see Appendix H) when talking about their building experience.
- Slightly more than one-third of interviewees identified and described at least one engineering solution (e.g., framing or cross-bracing) that helps a building stand and about one-third identified one or more physical properties of basic building materials.

DISCUSSION

Chicago Children's Museum (CCM) has created rich and engaging visitor experiences for adults and their children through *Skyline,* an exhibition funded by the National Science Foundation. As is evident from these summative evaluation findings, visitors' experiences in *Skyline* are overwhelmingly positive, and CCM successfully achieved most of its intended impacts. Further, CCM successfully used learning and reflection to design an exhibition that supports parent-child collaboration and STEM-based learning. One explanation for its success is that *Skyline* underwent several stages of evaluation to inform planning and development toward achieving its intended impacts. In July 2004, RK&A conducted a front-end evaluation in *Under Construction*, an existing exhibition about building. The study provided baseline data about the experiences of adult caregivers and children, including potential gender biases. Subsequent rounds of formative evaluation refined the effectiveness of select exhibits. The following discussion explores findings from the third and final phase of evaluation through the lens of *Skyline*'s intended impacts.

VISITORS' UNDERSTANDING OF STEM-BASED CONCEPTS

One intended impact of *Skyline* is "families gain a new understanding of how buildings stand up by increasing their understanding of relevant STEM concepts (see Appendix H)." CCM developed five indicators (see Table 1 below) as evidence of achieving this result. Findings show that more visitors performed the desired behaviors in *Skyline* compared to *Under Construction* (RK&A, 2004).

TABLE I

CORRELATION OF *SKYLINE* INDICATORS AND PRINCIPAL FINDINGS FOR IMPACT ONE: *FAMILIES GAIN A NEW UNDERSTANDING OF HOW BUILDINGS STAND UP BY INCREASING THEIR UNDERSTANDING OF STEM CONCEPTS*

INDICATORS FOR IMPACT ONE	INDICATOR ACHEIVED	SUPPORTING FINDINGS
More than 50 percent of girls engage in building	Yes	71 percent of children engaged in building; there were no statistically significant differences between male and female children
More than 65 percent of children attempt to build a structure (i.e., connect building materials)	Somewhat	58 percent of children attempted to build a structure—an improvement from the front-end evaluation where 36 percent attempted to build a structure
More than 11 percent of children build a stable, free standing structure	Yes	40 percent of children built a stable, free standing structure
Participants in one-half of visitor groups who participate in the exhibition use STEM-based vocabulary when talking about their building experience	Yes	Three-quarters of adult interviewees and slightly more than one-half of child interviewees used STEM-based vocabulary when talking about their building experience
Participants in one-half of visitor groups who complete the photo-narrative experience use relevant STEM-related language when talking about their building experience	Yes	Slightly more than one-half of visitor groups used relevant STEM-related language when talking about their building experience

Notably, data collected from this summative evaluation show that all five indicators were achieved, with one small exception—58 percent of children rather than the desired 65 percent attempted to build a structure; nevertheless, these data still show a significant improvement over the front-end evaluation in children's attempts to and ultimate success in creating stable, free-standing structures. The four remaining indicators were achieved as follows:

- Observation data show that almost three-quarters of children engaged in building and no statistically significant difference was found between male and female children whereas in the front-end evaluation, data showed that males were more likely to build than females;
- 40 percent of observed children successfully created a stable, free-standing structure;
- Three-quarters of adult interviewees and slightly more than one-half of child interviewees used STEM-based concepts when discussing their building experience; and,
- Slightly more than one-half of visitor groups (who gave permission for RK&A to analyze their photo-narrative experience) used STEM-based concepts when discussing their building experience.

It is quite remarkable for a museum exhibition to affect how visitors talk about a science idea. Changes in learning typically require repeat exposure to science concepts and facilitation of learning by a facilitator, yet most visitors attended *Skyline* once for a median time of about 23 minutes. Often visitors remain "fixed" in their understanding (or lack of understanding) of subject matter, and introducing a

new idea through an exhibition is extremely difficult. Thus, findings at CCM are notable: 40 percent of children created stable, free-standing structures and three-quarters of adults and one-half of child interviewees who participated in the *Skyline* exhibition articulated STEM-based concepts when discussing their building experience.

The *Skyline* exhibition's successful delivery of STEM concepts could be due to the elegant simplicity of its design, something adults spoke enthusiastically about during interviews, and the reinforcement of one clear exhibition message—tall buildings stand up through the use of framing and support bracing. The *Skyscraper Challenge* (i.e., photo-narrative experience), large-scale building area, and auxiliary exhibits designed for *Skyline* gave visitors several straightforward and interactive ways to explore this exhibition message, and each exhibit reinforces STEM learning opportunities of another exhibit by consistently focusing on this one important idea. Further, *Skyline* expands on an already familiar concept to many children and their parents—building or connecting materials together. Instead of focusing on many complex science concepts and delivering these through passive means, as some science exhibitions tend to do, CCM facilitated visitors' learning of STEM concepts by focusing on one clear idea and presenting it consistently, while also providing opportunities for visitors to explore this idea in multiple, interactive ways.

CAREGIVERS' ROLE IN FACILITATING CHILDREN'S LEARNING

A second intended impact of the *Skyline* exhibition is "caregivers who take advantage of the *Skyline* exhibition are confident and skillfully facilitate their children's learning." CCM developed four indicators (see Table 2) to demonstrate whether they achieved this impact.

TABLE 2

CORRELATION OF *SKYLINE* INDICATORS AND PRINCIPAL FINDINGS FOR IMPACT TWO: *CAREGIVERS WHO TAKE ADVANTAGE OF THE SKYLINE EXHIBITION ARE CONFIDENT AND SKILLFULLY FACILITATE THEIR CHILDREN'S LEARNING*

INDICATORS FOR IMPACT TWO	INDICATOR ACHEIVED	SUPPORTING FINDINGS
More than 41 percent of children work collaboratively—work together equally or the adult follows the child's lead 75 percent of the time—in the large-scale building activity	No	40 percent of children worked collaboratively with their caregivers during the building activity; however, there is no statistically significant difference between the front-end and summative evaluations
More than 58 percent of children are coached by their caregivers while building a structure	Somewhat	66 percent of children were coached by their caregivers; however, there is no statistically significant difference between the front-end and summative evaluations
More than 40 percent of girls are coached by their caregivers	Yes	66 percent of children were coached by their caregivers; there were no statistically significant differences between male and female children
More than 40 percent of children will have strategies or tool-use modeled by their caregivers while building a structure	Yes	84 percent of children had strategies or tool-use modeled by their caregiver while building a structure

Two of the above indicators were successfully achieved—there was no statistically significant difference between adults' coaching behavior of male versus female children, whereas in the front-end evaluation, adults were more likely to coach male children; and, caregivers modeled building strategies or tool use to 84 percent of children. One indicator was somewhat achieved—the number of children who were coached by their caregivers increased from the front-end to summative evaluation (58 percent compared to 66 percent, respectively), but this increase, while notable, was not statistically significant.

One indicator was not achieved—40 percent of children and adults worked collaboratively to build their structure instead of the desired 41 percent or more; however, there was a statistically significant increase in the *number* of children who worked with their caregivers to build compared with the front-end evaluation (73 percent in the summative evaluation versus 51 percent in the front-end evaluation).[2] Further, 48 percent of children and adults observed in the photo-narrative experience of *Skyline* worked collaboratively to build their structure; while there is no baseline data to test the significance of this finding, it still suggests that there were exhibits in *Skyline* where parent-child collaboration was frequent, possibly due to the fact that the photo-narrative experience is structured and gives visitors a specific goal to achieve within a certain time period (i.e., constructing the tallest, most stable building).

Adult interviews shed additional light on how caregivers worked with their children. Three-quarters of adult interviewees said they worked with their child during the building process and nearly all said it was an extremely satisfying experience (the degree to which adults worked with their children is unclear). Further, some adults said that the exhibition's organization and simple design (e.g., materials were easy to use and identify) had helped them work with their child to build, and several said the presence of other visitors' structures or the information about triangles was helpful to them as they built. Notably, the summative observation data show a statistically significant increase in the number of structures that remained intact throughout the exhibition area compared to the front-end evaluation. Clearly, some caregivers relied on these structures to help them build with their child.

Adults overwhelmingly described their *Skyline* experience as positive, expressing extreme enthusiasm for the exhibition's open-ended and simplistic design, which they said promotes creativity and independent learning, and as indicated above, helped them build with their child. Museum exhibitions, such as *Skyline*, promote creativity and imagination and allow users to drive their own learning, which can help build families' confidence as informal learners and create memorable experiences (Beach and Gibans, 1992). Thus, adults' enthusiasm for the exhibition's design might help to explain why more adults were willing to accept the challenge of working with and teaching their children, and why they described this collaboration as extremely satisfying. Further, research suggests that successful family learning exhibitions are those that are accessible to multiple users and encourage multiple outcomes (Borun et. al., 1998), something that interviewees mentioned when talking about *Skyline*.

[2] Working collaboratively was defined as a child and adult working together equally or the adult following the child's lead at least 75 percent of the time. Thus, it is important to note that while there was a significant increase in the *number* of children who worked with their caregivers at least once during the observation period, this finding does not necessarily speak to the quality of that interaction.

VISITORS' AWARENESS OF STEM-BASED LEARNING

The third and final impact of the *Skyline* exhibition was that "caregivers and children who participated in the photo-narrative experience are aware of their own STEM learning." CCM developed one indicator to demonstrate whether they achieved this impact (see Table 3).

TABLE 3

CORRELATION OF *SKYLINE* INDICATORS AND PRINCIPAL FINDINGS FOR IMPACT THREE: *CAREGIVERS AND CHILDREN WHO PARTICIPATED IN THE PHOTO-NARRATIVE EXPERIENCE ARE AWARE OF THEIR OWN STEM LEARNING*

INDICATORS FOR IMPACT THREE	INDICATOR ACHIEVED	SUPPORTING FINDINGS
One-half of visitors articulate one or more learning processes and outcomes that reference STEM-based content	Somewhat	One-third of visitor groups who participated in the photo-narrative experience articulated learning processes that referenced STEM-based content; however, one-half of visitor groups used STEM-based concepts when talking about their building experience

The indicator above was somewhat achieved; when prompted to talk about what they learned or would remember from making their building, about one-third of visitor groups (who gave permission for their photo-narrative experience to be analyzed), articulated learning processes or outcomes that referenced STEM-based content. As discussed above, one-half of these visitor groups used STEM-based concepts when talking about their overall building experience, however not all of them expressed an explicit awareness of STEM-based learning.

Given the open-ended nature of the photo-narrative prompt questions about what visitors learned or would remember, it is still notable that one-third referenced an awareness of STEM-based learning. CCM plans to further explore how the photo-narrative experience affects parent-child collaboration and visitors' awareness of STEM-based learning through subsequent research projects whose primary focus will be to deconstruct this experience. This is a worthy research goal as it will help clarify the effectiveness of the photo-narrative experience in furthering visitors' awareness of their own learning while in the *Skyline* exhibition and what CCM might do to enhance this awareness.

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INTRODUCTION

This report presents the findings from a summative evaluation of the National Science Foundation-funded *Skyline* exhibition conducted by Randi Korn & Associates, Inc. (RK&A) for Chicago Children's Museum (CCM). RK&A conducted this evaluation to examine the extent to which the exhibition achieved its intended impacts. Data for this study were collected from July through mid-August 2008.

Specifically, the summative evaluation explores whether:

- Families that visit the exhibition increase their understanding of relevant Science, Technology, Engineering, and Math (STEM) concepts related to how buildings stand up;
- Caregivers who take advantage of the exhibition gain confidence and skills in facilitating their children's learning; and,
- Caregivers and children who participate in the photo-narrative experience are aware of their own STEM-based learning.

METHODOLOGY

RK&A used three data collection strategies to assess visitors' experiences in the exhibition: observations, in-depth interviews, and photo-narrative documentation.

OBSERVATIONS

Visitor observations provide an objective and quantitative account of how visitors behave and react to exhibition components. Observational data indicate how much time visitors spend within the exhibition and suggest the range of visitor behaviors.

Children 4 to 10 years old visiting with family groups were eligible to be unobtrusively observed in the exhibition. The data collector selected visitors to observe using a continuous random sampling method. In accordance with this method, the observer stationed herself at the exhibition's entrance and selected the first eligible child to enter the exhibition. Observers recorded select behaviors of the child and accompanying caregiver, total time spent in the exhibition, and sub-times spent building a structure in individual exhibit areas. When the visitor completed his or her visit, the observer intercepted the caregiver of the selected child and asked relevant demographic and visit information (see Appendix A for the observation form and Appendix B for the definitions of behaviors). Upon completing the observation, observers summarized the child and caregiver's overall behavior in the exhibition using multiple choice responses (see the last two pages of the observation form, Appendix A). The observer then returned to the entrance to await the next eligible visitor to enter the exhibition (see Appendix C for a more detailed description of the observation protocol).

IN-DEPTH INTERVIEWS

Open-ended interviews produce data rich in information because interviewees are encouraged and motivated to describe their experiences, express their opinions and feelings, and share with the interviewer the meaning they constructed during a visit. Upon entering the exhibition, children 5 to 10 years old and adults visiting with family groups and at least one child aged 5 to 10 were eligible to be selected for participation in an interview following a continuous random sampling method, as described in the section above. When the selected visitor was finished building their structure, the interviewer

invited him or her to answer several questions about their exhibition experience (see Appendix D for the child interview guide and Appendix E for the adult interview guide). Each interview guide was intentionally open-ended to allow interviewees to discuss what they felt was meaningful. Children's responses were hand-written verbatim during the interview and adult interviews were audio-recorded with participants' permission and transcribed to facilitate analysis.

PHOTO-NARRATIVE DOCUMENTATION

As part of their *Skyline* exhibition experience, visitors can participate in the *Skyscraper Challenge*, a multimedia exhibit where the goal is to build the tallest, most stable building possible within the time limit given. A computer takes pictures of visitors as they work and when time expires, prompts visitors to choose six pictures to tell a story about their building experience. To facilitate story-telling, the computer asks six questions, one to accompany each picture (see Appendix F for the photo-narrative prompt questions), and audio-records visitors' responses. CCM refers to this as photo-narrative documentation. Visitors can access their photo-narrative via CCM's Web site using a unique id number assigned to them before starting their experience.

Upon exiting the *Skyscraper Challenge*, the data collector selected adults visiting with family groups and at least one child aged 5 to 10 and asked for signed permission to access their group's photo-narrative experience for use in the evaluation. These visitors were selected following a continuous random sampling method, as described in the observation section above. When data collection was complete, photo-narratives were accessed for visitor groups who gave their permission and the audio-recordings of their responses were transcribed to facilitate analysis.

DATA ANALYSIS

QUANTITATIVE ANALYSIS

Observation data are quantitative and were analyzed using SPSS 12.0.1 for Windows, a statistical package for personal computers. Analyses included both descriptive and inferential methods. Within the body of the report, only statistically significant findings ($p \leq .01$) are presented; however, all statistical analyses run are listed in Appendix G.[3]

DESCRIPTIVE STATISTICS

Frequency distributions were calculated for all categorical variables. For ratio-level variables, such as "total time in the exhibition," summary statistics, including the range and median (data point at which half the responses fall above and half fall below), were also calculated.[4]

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[3] When the level of significance is set to $p = 0.01$, any finding that exists at a probability (p-value) ≤ 0.01 is "significant." When a finding (such as a relationship between two variables) has a p-value of 0.01, there is a 99 percent probability that the finding exists; that is, 99 out of 100 times, the finding is correct. Conversely, there is a 1 percent probability that the finding does not exist; in other words, 1 out of 100 times, the finding appears by chance.

[4] Medians rather than means are reported in this document because, as is typical, the number of exhibits used and the time spent by visitors were distributed unevenly across the range. For example, whereas most visitors spent a short to moderate amount of time in the exhibition, a few spent an unusually long time. When the distribution of scores is extremely asymmetrical (i.e., "lopsided"), the mean is affected by the extreme scores and, consequently, falls further away from the distribution's central area. In such cases, the median is a better indicator of the distribution's central area because it is not sensitive to the values of scores above and below it—only to the number of such scores.

INFERENTIAL STATISTICS

To examine the relationship between two categorical variables, cross-tabulation tables were computed to show the joint frequency distribution of the variables, and the chi-square statistic (X^2) was used to test the significance of the relationship. For example, "adult coaches child on how to build" was tested against "gender" to determine whether the two variables are related. To test for differences in the medians of two or more groups, the nonparametric Kruskal-Wallis (K-W) test was performed.[5] For example, "total time in the exhibition" was compared by "age group" to determine whether time spent in the exhibition is age-related.

QUALITATIVE ANALYSIS

The interview data are qualitative, meaning that results are descriptive, following from the interviews' conversational nature. In analyzing the data, the evaluator studies responses for meaningful patterns, and, as patterns emerge, groups similar responses. To illustrate interviewees' ideas as fully as possible, verbatim quotations (edited for clarity) are included.

REPORTING METHOD

For the observation data, information is displayed in tables. Percentages within tables may not always equal 100 owing to rounding. The findings within each topic are presented in descending order, starting with the most-frequently occurring.

The interview data are presented in narrative. The interviewer's remarks appear in parentheses, and an asterisk (*) signifies the start of a different speaker's comments. In the in-depth interview sections of the report (child and adult), the interviewee's gender and age are indicated in brackets. In the photo-narrative section of the report, whether the interviewee is an adult or child is indicated in brackets. Trends and themes in the data are presented from most- to least-frequently occurring.

SECTIONS OF THE REPORT:

1. Principal Findings: Observations
2. Principal Findings: In-Depth Child Interviews
3. Principal Findings: In-Depth Adult Interviews
4. Principal Findings: Photo-narrative Experience

[5] The Kruskal-Wallis (K-W) test is a nonparametric statistical method for testing the equality of population medians of two or more groups. Nonparametric statistical methods do not assume that the underlying distribution of a variable is "normal" with a symmetric bell-shape, so they are appropriate for testing variables with asymmetric distributions such as "total time in the exhibition." The K-W test is analogous to a One-way Analysis of Variance, with the scores replaced by their ranks. The K-W test statistic H has approximately a chi-square distribution.

PRINCIPAL FINDINGS: OBSERVATIONS

Observation data for the summative evaluation of the *Skyline* exhibition were collected in July 2008 at CCM. Data collectors trained by RK&A observed a total of 100 children in the target age range of 4 to 10 years old. *Skyline* features three main areas: large-scale building area (LSBA), photo-narrative experience (PE), and auxiliary exhibits. Data are presented for the whole exhibition and by individual area. In addition, comparisons are made between *Skyline's* large-scale building area and the previous building exhibition called, *Under Construction*.

WHOLE EXHIBITION

DATA COLLECTION CONDITIONS

A majority of observations took place on weekdays (82 percent) and slightly less than one-quarter took place on Sunday (18 percent) (see Table 4). Nearly two-thirds of visitors experienced a low to moderate level of crowding (62 percent).

TABLE 4

DATA COLLECTION CONDITIONS

DAY OF THE WEEK (*n* = 97)[1]	%
Thursday (regular hours)	22.7
Thursday (free evening hours)	23.7
Friday (regular hours)	21.6
Friday (evening hours)	14.4
Sunday	17.5
LEVEL OF CROWDING (*n* = 91)	**%**
Low	8.8
Moderate	52.7
High	38.5

[1]RK&A was not able to collect data on Saturdays because another research team was using the exhibition for their study.

VISITOR DESCRIPTIONS

OBSERVED CHILD

As shown in Table 5, the children observed included slightly more girls than boys (52 percent and 49 percent, respectively). The children ranged in age from 4 to 12 years (the target age range being 4 to 10), with a median age of 6 years.

TABLE 5

OBSERVED CHILD DEMOGRAPHICS

GENDER (*n* = 97)	**%**
Female	51.5
Male	48.5
AGE (*n* = 98)[1]	**%**
4 to 5 years	34.7
6 to 7 years	30.6
8 to 9 years	24.5
10 to 11 years	8.1
12 years	2.0
ETHNICITY (*n* = 98)[2]	**%**
Caucasian	54.1
Multiple/Unsure	14.3
Asian/Pacific Islander	11.2
African American	11.2
Hispanic/Latino	9.2

[1]As the observed child exited the exhibition, the data collector asked the accompanying adult the ages of all the children in the group and then indicated which one was the observed child.
[2]Data collectors guessed the child's ethnicity.

ADULTS AND CHILDREN ACCOMPANYING OBSERVED CHILD

All of the observed children visited *Skyline* with one or more adults (median = two adults). More than one-half were accompanied by female and male adults (60 percent) (see Table 6). Almost three-quarters of the observed children were accompanied by one or more other children (70 percent) (median = one other child). One-half were accompanied by one or more children of the opposite gender (50 percent).

TABLE 6

GENDERS OF ADULTS AND CHILDREN ACCOMPANYING OBSERVED CHILD

ACCOMPANYING ADULTS (*n* = 100)	TOTAL %
Both female and male adults	60.0
Female adult(s)	29.0
Male adult(s)	11.0
ACCOMPANYING CHILDREN (*n* = 70)	**TOTAL %**
Mixed genders of observed child and accompanying child(ren)	50.0
Female observed child with other female child(ren)	27.1
Male observed child with other male child(ren)	22.9

Most observed children were visiting with adults of child-bearing age—40 percent were accompanied by one or more adults 25 to 34 years of age and 54 percent by adults 35 to 44 years of age (see Table 7). The observed children who were accompanied by other children had diverse playmates: 51 percent of the other children were under 4 years of age, 57 percent were between 4 and 7 years, 36 percent were between 8 and 11 years, and 13 percent were 12 years or older (median age of accompanied children = 5 years).

TABLE 7

AGES OF ADULTS AND CHILDREN ACCOMPANYING OBSERVED CHILD

APPROXIMATE AGE OF ACCOMPANYING ADULTS (*n* = 100) [1]	%
Under 25 years	7.0
25 to 34	40.0
35 to 44	54.0
45 years or older	17.0
AGE OF ACCOMPANYING CHILDREN (*n* = 70)[1/2]	**%**
Under 4 years	51.4
4 to 7 years	57.1
8 to 11 years	35.7
12 years or older	12.9

[1]The total percentage exceeds 100 because observed children were accompanied by adults and children in multiple age categories.
[2]As the observed child exited the exhibition, the data collector asked the accompanying adult the ages of all the children.

VISITATION CHARACTERISTICS

As the observed child exited the exhibition, the observer asked the accompanying adult whether it was the group's first visit to CCM and their first visit to *Skyline*. Two-thirds of the groups were first-time CCM visitors and one-third were repeat visitors (67 percent and 33 percent, respectively) (see Table 8). Of repeat visitors, two-thirds were visiting *Skyline* for the first time (68 percent).

TABLE 8

VISITATION CHARACTERISTICS

VISIT TO CCM (*n* = 93)	%
First-time CCM visitor	66.7
Repeat CCM visitor	33.3
VISITS TO *SKYLINE* (*n* = 31)	**%**
First-time visitor to *Skyline*	67.7
Repeat visitor to *Skyline*	32.3

OVERALL VISITATION PATTERNS

TOTAL TIME SPENT IN THE EXHIBITION

Observed children's total time in *Skyline* ranged from about 5 minutes to more than 1 hour (see Table 9)(median = 22 minutes:38 seconds). When the total time spent in the exhibition was examined by demographic and visitation characteristics, no statistically significant differences were found.

TABLE 9

TOTAL TIME IN THE EXHIBITION

TIME (MIN:SEC) (*n* = 100)	%
Less than 10:00	6.0
10:00 – 19:59	28.0
20:00 – 29:59	42.0
30:00 or more	24.0
SUMMARY STATISTICS	**HR:MIN:SEC**
Range	4:31 to 1:22:09
Median time	22:38

DECISION TO LEAVE EXHIBITION

As Table 10 shows, for more than one-half of the observed children the decision to leave *Skyline* was mutual among the children and adults (57 percent). For one-third of the observed children, the adult(s) accompanying them initiated leaving the exhibition (33 percent).

TABLE 10

VISITOR WHO INITIATES LEAVING *SKYLINE*

DECISION MAKER (*n* = 94)	%
Mutual	57.4
Adult(s)	33.0
Selected child	6.4
Other child(ren)	3.2

EXHIBITION AREAS VISITED

As noted earlier, *Skyline* features three main areas: large-scale building area (LSBA), photo-narrative experience (PE), and auxiliary exhibits. As shown in Table 11, 41 percent of observed children visited only the photo-narrative experience and 38 percent visited only the large-scale building area. No statistically significant differences were found among demographic characteristics and sections visited. In other words, the large-scale building area and the photo-narrative experience attracted similar audiences.

TABLE 11

EXHIBITION SECTIONS VISITED

SECTION (*n* = 100)	%
Only visited PE	41.0
Only visited LSBA	38.0
Visited LSBA and one or more auxiliary exhibits	10.0
Visited both LSBA and PE but no auxiliary exhibits	7.0
Visited PE and one or more auxiliary exhibits	2.0
Visited LSBA, PE, and one or more auxiliary exhibits	2.0

LARGE-SCALE BUILDING AREA

This section presents data from the large-scale building area (LSBA) collected during the summative evaluation of *Skyline*. To gauge the impact of *Skyline*, RK&A compared data from the LSBA with data from CCM's previous building area, *Under Construction* (UC), which were collected during the front-end evaluation as baseline data.

During the summative evaluation of *Skyline*, 56 visitors were observed in the large-scale building area and, in the front-end evaluation, 55 visitors were observed in *Under Construction*.

DATA COLLECTION CONDITIONS DIFFERENCES

RK&A found one difference in the data collection conditions between the front-end and summative evaluations (see Table 12). During most of the observations in the large-scale building area there were many existing structures; whereas in *Under Construction* there tended to be fewer structures.

TABLE 12

DIFFERENCES IN DATA COLLECTION CONDITIONS BETWEEN LSBA AND UC

NUMBER OF EXISTING STRUCTURES (LSBA *n* = 53, UC *n* = 54)[1/2]	LSBA %	UC %
Bare	0.0	29.6
Few/moderate	24.5	35.2
Many	75.5	35.2

[1]An "existing structure" is any construction made by a visitor and left intact when s/he exited the exhibition.
[2]χ^2=24.592; df=2; p=.000

DEMOGRAPHIC DIFFERENCES

RK&A found two demographic differences between children observed in the large-scale building area and those in *Under Construction* (see Table 13). The large-scale building area attracted older children compared to *Under Construction*—which is to be expected because the target audience shifted slightly between the two studies. In *Skyline* the target audience was children between 4 and 10 years and in *Under Construction* it was children between 4 and 7 years.

The large-scale building area also attracted more girls than boys compared to *Under Construction*.

TABLE 13

DIFFERENCES IN DEMOGRAPHICS OF OBSERVED CHILDREN BETWEEN LSBA AND UC

AGE GROUP (LSBA *n* = 54, UC *n* = 54)[1]	LSBA %	UC %
4 to 7 years	70.4	96.3
8 to 12 years	29.6	3.7
GENDER (LSBA *n* = 53, UC *n* = 54)[2]	**LSBA %**	**UC %**
Female	56.6	37.0
Male	43.4	63.0

[1]χ^2=13.067; df=1; p=.000 [2]χ^2=4.114; df=1; p=.043

RK&A found two differences in the group composition between children observed in the large-scale building area and *Under Construction* (see Table 14). More children in the large-scale building area were accompanied by both male and female adults (59 percent) compared to children in *Under Construction* (35 percent). Additionally, children in the large-scale building area were visiting in larger family groups (median = 4 people per group) than children in *Under Construction* (median = 2 people per group).

TABLE 14

DIFFERENCES IN GROUP COMPOSITION BETWEEN LSBA AND UC

ADULTS GENDER (LSBA *n* = 56, UC *n* = 55)[1]	LSBA %	UC %
Both male and female adults	58.9	34.5
Only female adult(s)	32.1	47.3
Only male adult(s)	8.9	18.2
TOTAL GROUP SIZE (LSBA *n* = 56, UC *n* = 55)[2]	**LSBA %**	**UC %**
Median number of people (children + adults)	4.0	2.0

[1] χ^2=6.882; df=2; p=.032 [2] χ^2=10.019; df=1; p=.003 (Kruskal-Wallis test)

LSBA TIME SPENT BUILDING

During the front-end and summative evaluations, the observers noted how much time children spent building (i.e., connecting materials together). A total of 76 visitors were observed building (36 in UC and 40 in LSBA). Children in the large-scale building area spent more time building than did those in *Under Construction*—nearly three times as long (see Table 15). The time spent building did not differ by data collection conditions, demographics, or group composition.

TABLE 15

DIFFERENCES IN TIME SPENT BUILDING BETWEEN LSBA AND UC

	LSBA MIN:SEC	UC MIN:SEC
Median time (n = 111)[1]	22:34	8:54

[1] χ^2 = 15.253; df = 1; p = .000 (Kruskal-Wallis test)

LSBA BEHAVIORS

ENGAGEMENT WITH THE EXHIBITION

Data collectors noted five general behaviors in the large-scale building area (see Appendix B for a complete description of each behavior).

Nearly all observed children gathered materials and/or engaged in planning (95 percent) (see Table 16). During the course of the observations, 71 percent of observed children built with materials one or more times. One-third also used the materials but did not build one or more times (38 percent). Another one-third engaged in exhibit-related pretend play one or more times (34 percent).

No statistically significant differences were found in children's engagement in these five behaviors between the large-scale building area and *Under Construction*.

Additionally, when children's engagement in these five behaviors in the large-scale building was examined by data collection conditions, demographics, and group composition, no statistically significant differences were found. This finding directly contrasts the front-end study in *Under Construction* which found older children (over 5 years of age) and boys were more likely to build than younger children and girls.

TABLE 16

HOW OBSERVED CHILDREN ENGAGED WITH LSBA

BEHAVIOR (*n* = 56)	LSBA %[1]
Child plans/gathers materials	94.6
Child builds with materials	71.4
Child uses materials; does not build	37.5
Child engages in exhibit-related pretend play	33.9
Child's play is non-exhibit related	23.2

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

BEHAVIORS ASSOCIATED WITH BUILDING

Of the 56 children observed in the large-scale building area, 40 engaged in building (i.e., pieced materials together). Data collectors noted six behaviors associated with building (see Appendix B for a complete description of each behavior). About two-thirds of observed children added onto others' structures and about two-thirds started their own structures (each 70 percent) (see Table 17). In terms of tool use, more than three-quarters of observed children properly used tools (80 percent). During the observation period, about two-thirds of children also used their hands—rather than tools—to piece together materials (70 percent).

No statistically significant differences were found in children's behaviors associated with building.

TABLE 17

BEHAVIORS ASSOCIATED WITH BUILDING IN LSBA

USE OF MATERIALS (*n* = 40)	LSBA %[1]
Child adds onto others' structure	70.0
Child pieces materials together to create new structure	70.0
Child takes structures apart/cleans up	40.0
USE OF TOOLS (*n* = 40)	**LSBA %[1]**
Child properly uses tools	80.0
Child does not use tools (e.g., uses fingers instead of nut driver)	70.0
Child improperly uses tools	10.0

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period. (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

At the end of the observation, data collectors were asked to summarize the child's building activity in the large-scale building area using multiple-choice responses (see Appendix A for the observation form). The first summary question asked data collectors to describe who led the building activity (see Table 18). Slightly more than one-third of the observed children worked collaboratively with their adult caregivers(40 percent)[6], while one-quarter each either worked on their own or were led through the activity by an adult (each 25 percent).

No statistically significant differences were found for the leader of the building activity.

TABLE 18

LEADER OF BUILDING ACTIVITY IN LSBA

LEADER (*n* = 40)	LSBA %
Adult and observed child worked collaboratively[5]	40.0
Observed child worked on his/her own	25.0
Adult led the activity	25.0
Other child led the activity	10.0

The second summary question asked data collectors to summarize the quality of the observed children's structures. The quality of the observed children's structures in the large-scale building area varied: 43 percent pieced materials together but did not create an actual structure and 40 percent built a structure that stood (see Table 19).

When RK&A compared the quality of the structures in the front-end and summative evaluation, two differences emerged (see Table 19). Children in the large-scale building area were more likely to create structures that stood (40 percent) compared to children in *Under Construction* (11 percent). Conversely, children in *Under Construction* were more likely to piece materials together but not create a structure (64 percent) compared to children in the large-scale building area (43 percent).

TABLE 19

DIFFERENCES IN THE QUALITY OF STRUCTURES IN LSBA AND UC

STRUCTURE TYPE (LSBA *n* = 40, UC *n* = 36)[1]	LSBA %	UC %
Child builds but does not create a structure	42.5	63.9
Created a structure that stands	40.0	11.1
Created a structure but it does not stand	17.5	25.0

[1] $\chi^2=8.162$; df=2; $p=.017$

[6] Working collaboratively was defined as a child and adult working together equally or the adult following the child's lead at least 75 percent of the time.

The third summary question asked data collectors to estimate the size of the observed children's structures (see Table 20). Of the observed children who created structures, nearly one-half made structures two- to four-feet tall (44 percent), while more than one-third made structures under two-feet tall (39 percent). Size the children's structures did not differ by data collection conditions, demographics, or group composition.

TABLE 20

SIZE OF STRUCTURES IN LSBA

STRUCTURE SIZE (*n* = 23)	LSBA %
Under 2 feet	39.1
2 to 4 feet	43.5
Over 4 feet	17.4

The fourth summary question asked data collectors to summarize the observed children's role in making the structures stand (see Table 21). Of the 16 observed children who created standing structures in the large-scale building area, six were somewhat responsible for the structure standing, five were primarily responsible, and another five followed the directions of others.

TABLE 21

ROLE OF OBSERVED CHILDREN IN BUILDING A FREE-STANDING STRUCTURE IN LSBA

ROLE (*n* = 16)	LSBA *n*
Somewhat responsible for the structure standing	6
Primarily responsible for the structure standing	5
Followed directions of others which made the structures stand	5

The fifth summary question asked data collectors to summarize how triangular and diagonal braces were used in the observed child's structure if his/her structure stood. Of 16 standing structures, 11 used either triangular or diagonal braces to help the structure stand (four used triangular braces and seven used diagonal braces; no structures used both) (see Tables 22 and 23).

TABLE 22

USE OF TRIANGULAR BRACES IN STANDING STRUCTURES IN LSBA

DESCRIPTION (*n* = 16)	LSBA *n*
Triangular braces not used in structure	10
Triangular braces used in structure to help it stand[1]	4
Triangular braces used in structure, but only for decoration	2

[1]In one of the four structures, the observed child followed the directions of others to use the triangular braces; in the remaining three structures, someone in the observed child's group was responsible for using the triangular braces.

TABLE 23

USE OF DIAGONAL BRACES IN STANDING STRUCTURES IN LSBA

DESCRIPTION (*n* = 16)	LSBA *n*
Diagonal braces not used in structure	7
Diagonal braces used in structure to help it stand[1]	7
Diagonal braces used in structure, but only for decoration	2

[1]In four of the seven structures, the observed child followed the directions of others to use the diagonal braces; in the remaining three structures, someone in the observed child's group was responsible for using the diagonal braces.

LSBA SOCIAL INTERACTIONS

GENERAL INTERACTIONS

The observed child most often used the large-scale building area with one or more accompanying adults, followed by other children in his/her group (73 percent and 66 percent, respectively) (see Table 24).

TABLE 24

WITH WHOM OBSERVED CHILD USED LSBA

INTERACTION	LSBA %[1]
Child uses exhibition with adult(s) in own group (*n* = 56)	73.2
Child uses exhibition with other child(ren) in own group (*n* = 41)	65.9
Child uses exhibition alone (*n* = 56)	44.6
Child uses exhibition with child(ren) from other group (*n* = 56)	8.9
Child uses exhibition with adult(s) from other group (*n* = 56)	8.9
Staff interaction: logistics (*n* = 56)	1.8
Staff interaction: content (*n* = 56)	1.8

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period. (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

When RK&A compared the front-end and summative data, one difference in social interaction emerged (see Table 25). Children in the large-scale building area were more likely to work with their accompanying adults (73 percent) than were children in *Under Construction* (51 percent).[7]

TABLE 25

DIFFERENCES IN SOCIAL INTERACTION IN LSBA AND UC

INTERACTION (LSBA *n* = 56, UC *n* = 55)[1]	LSBA %	UC %
Child uses exhibition with adult(s) in own group	73.2	50.9

[1]χ^2=5.869; df=1; p=.015

[7] Worked with their accompanying adult is defined as an observed child working with the adult in their visiting group one or more times during the observation period.

ADULT-CHILD INTERACTIONS

Data collectors noted seven specific adult-child interactions in the large-scale building area (see Appendix B for a complete description of each behavior). Table 26 summarizes the specific interactions that took place between adults and the observed children.

Three-quarters of observed children were provided with physical assistance by an adult in manipulating and/or building with the materials (75 percent). About three-quarters of observed children (73 percent) used the exhibit on their own—that is, their accompanying adult(s) did not interact with them—one or more times during the observation period. More than one-half of observed children were coached during building or had building modeled for them by adults (66 percent and 54 percent, respectively).

TABLE 26

SPECIFIC ADULT-CHILD INTERACTIONS IN LSBA

INTERACTION (*n* = 56)	LSBA %[1]
Adult provides physical assistance	75.0
Adult does not interact with observed child[2]	73.2
Adult coaches child on how to build	66.1
Adult models how to build	53.6
Adult disciplines/manages child	33.9
Adult models how to use tools	30.4
Adult discusses exemplar signs with child	0.0

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period. (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

[2]An error was found in the front-end evaluation when RK&A began comparative analysis with the summative data. In the front-end evaluation, "adult does not interact with observed child" should have been 69.1 percent not 41.8 percent which was stated in the report.

When the specific adult-child interactions in the large-scale building area were compared with data from *Under Construction*, one statistically significant difference was found (see Table 27). Observed children in the large-scale building area were more likely to be disciplined or managed by their accompanying adults (34 percent) than were children in *Under Construction* (9 percent).

When the specific adult-child interactions in the large-scale building area were examined by data collection conditions, demographics, and group composition, no statistically significant differences were found. This finding directly contrasts the front-end study in *Under Construction* which found adults were more likely to coach male children than they were female children.

TABLE 27

DIFFERENCES IN SPECIFIC ADULT-CHILD INTERACTIONS IN LSBA AND UC

INTERACTION (LSBA *n* = 56, UC *n* = 55)[1]	LSBA %	UC %
Adult disciplines/manages child	33.9	9.1

[1]χ^2=10.101; df=1; p=.001

Data collectors also noted eight behaviors that adults could exhibit instead of interacting with the observed children (see Appendix B for a complete description of each behavior). A total of 41 observed children were accompanied by adults who did not interact with them at some point during the observation period. For three-quarters of observed children, their accompanying adult engaged in non-exhibit-related activities or rested one or more times during the observation (74 percent) (see Table 28).

No statistically significant differences were found for these behaviors.

TABLE 28

HOW ADULT BEHAVED WHEN NOT INTERACTING WITH OBSERVED CHILD IN LSBA

ADULT BEHAVIOR (*n* = 41)	LSBA %[1]
Adult does non-exhibit-related activity or rests	73.9
Adult uses exhibition with other child(ren)	31.7
Adult takes care of other child(ren)	29.3
Adult builds own structure	17.1
Adult leaves exhibition	17.1
Adult looks at other exhibits in *Skyline*	14.6
Adult takes things apart/cleans up	12.2
Adult socializes with other adults	9.8

[1]The total percentage exceeds 100 because adults accompanying the observed children exhibited multiple behaviors over the observation period. (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

At the end of the observation, data collectors were asked to summarize the adult-child interactions using multiple-choice responses (see Appendix A for the observation form). Adults—both males and females—interacted little with the observed children during about one-third of the observations (40 percent for females and 40 percent for males) (see Table 29). During about one-quarter of the observations, adult males and females interacted once or twice with the observed child (23 percent for females and 26 percent for males).

No statistically significant differences were found in the overall role adults played in children's experiences.

TABLE 29

OVERALL ROLE ADULTS PLAYED IN CHILDREN'S EXPERIENCES IN LSBA

ADULT FEMALE (*n* = 52)	LSBA %
Interacted little with child	40.4
Once or twice coached, modeled, and/or helped child build	23.1
Played disciplinary and logistical role	17.3
Periodically coached, modeled, and/or helped child build	11.5
Consistently coached, modeled, and/or helped child build	7.7
ADULT MALE (*n* = 38)	**LSBA %**
Interacted little with child	39.5
Once or twice coached, modeled, and/or helped child build	26.3
Periodically coached, modeled, and/or helped child build	21.1
Consistently coached, modeled, and/or helped child build	7.9
Played disciplinary and logistical role	5.3

PHOTO-NARRATIVE EXPERIENCE

This section presents data from the photo-narrative experience (PE) collected during the summative evaluation of *Skyline*. The photo-narrative experience is unique to *Skyline* and, as such, there is no comparable baseline data from *Under Construction*.

During the summative evaluation of *Skyline*, 53 visitors were observed stopping in the photo-narrative experience.

DATA COLLECTION CONDITIONS

During nearly all of the observations in the photo-narrative experience (98 percent), there were many existing structures (see Table 30).

TABLE 30

DATA COLLECTION CONDITIONS IN PE

NUMBER OF EXISTING STRUCTURES (*n* = 50)	PE %
Bare	0.0
Few/moderate	2.0
Many	98.0

PE TIME SPENT BUILDING

Observers noted how much time children spent building (i.e., connecting materials together) in the photo-narrative experience. A total of 49 visitors were observed building (median = 15 minutes:25 seconds) (see Table 31).

The time spent building did not differ by data collection conditions, demographics, or group composition.

TABLE 31

TIME SPENT BUILDING IN PE

TIME (MIN:SEC) (*n* = 49)	PE %
Less than 10:00	2.0
10:00 – 19:59	69.4
20:00 – 29:59	24.5
30:00 or more	4.0
SUMMARY STATISTICS	**HR:MIN:SEC**
Range	7:12 to 41:15
Median time	15:25

PE BEHAVIORS

USE OF INSTRUCTIONAL MEDIA

In the photo-narrative experience data collectors noted how children and adults used the instructional media: how they looked at the introduction panel, scanned a building permit, saw an error message on the computer screen, listened to computer's instructions, and took the building permit upon exit.

Nearly all observed children and/or their companions scanned the building permit, listened to the computer instructions, and took their building permit upon exiting the exhibition (94 percent, 92 percent, and 85 percent, respectively) (see Table 32).

TABLE 32

USE OF INSTRUCTIONAL MEDIA

BEHAVIOR (*n* = 53)	PE %[1]
Scanned building permit	94.3
Listened to computer instructions	92.4
Child listened to computer instructions (*n* = 3)	
Adult listened to computer instructions (*n* = 5)	
Both listened to computer instructions (*n* = 41)	
Take building permit upon exit	84.9
Looked at introduction panel	34.0
Child looked at introduction panel (*n* = 1)	
Adult looked at introduction panel (*n* = 13)	
Both looked at introduction panel (*n* = 4)	
Saw error message on computer screen	1.9

[1]The total percentage exceeds 100 because observed children and adults exhibited multiple behaviors over the observation period. (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

ENGAGEMENT WITH THE EXHIBITION

Data collectors noted four general behaviors in the photo-narrative experience (see Appendix B for a complete description of each behavior). During the course of the observations, nearly all observed children built with materials one or more times (94 percent) (see Table 33). One-quarter also used the materials but did not build one or more times (23 percent).

TABLE 33

HOW OBSERVED CHILDREN ENGAGED WITH PE

BEHAVIOR (*n* = 53)	PE %[1]
Child builds with materials	94.3
Child uses materials; does not build	22.6
Child's play is non-exhibit related	17.0
Child engages in exhibit-related pretend play	9.4

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period. (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

BEHAVIORS ASSOCIATED WITH BUILDING IN PE

Nearly all observed children built with the adult(s) in their group (96 percent) (see Table 34). Of those accompanied by other children, three-quarters built with them (78 percent).

TABLE 34

HOW CHILD BUILDS IN PE

DESCRIPTION	PE %[1]
Observed child builds with adult(s) in group (n = 53)	96.2
Observed child builds with other child(ren) in group (n = 37)	78.4
Observed child builds on his/her own (n = 53)	1.9

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

During the observed children's building activity, nearly all adults provided physical assistance one or more times (98 percent) (see Table 35). More than three-quarters also coached and modeled how to build one or more times (83 percent and 79 percent, respectively). Few adults did not interact with the observed children (11 percent) and even fewer disciplined or managed them (9 percent).

When the role of adults during the building activity in the photo-narrative experience was examined by data collection conditions, demographics, and group composition, no statistically significant differences were found.

TABLE 35

ROLE OF ADULTS DURING BUILDING IN PE

INTERACTION (n = 53)	PE %[1]
Adult provides physical assistance	98.1
Adult coaches child on how to build	83.0
Adult models how to build	79.2
Adult does not interact with observed child	11.3
Adult disciplines/manages child	9.4

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

At the end of the observation, data collectors were asked to summarize the child's building activity in the photo-narrative experience using multiple choice responses (see Appendix A for the observation form). The first summary question asked data collectors to describe who led the building activity (see Table 36). For 50 percent of observed children, the adult(s) in their group led the building activity, while for 48 percent the observed child and adult(s) worked collaboratively.

No statistically significant differences were found for the leader of the building activity.

TABLE 36

LEADER OF BUILDING ACTIVITY IN PE

LEADER (*n* = 50)	PE %
Adult led the activity	50.0
Adult and observed child worked collaboratively	48.0
Observed child worked on his/her own	2.0
Other child led the activity	0.0

The second summary question asked data collectors to summarize the quality of the observed children's structures (see Table 37). In the photo-narrative experience, about three-quarters of observed children and/or their companions created structures that stood (72 percent).

TABLE 37

QUALITY OF STRUCTURES IN PE

STRUCTURE TYPE (*n* = 50)	PE %
Created a structure that stands	72.0
Child builds but does not create a structure	14.0
Created a structure but it does not stand	14.0

The third summary question asked data collectors to note the size of the observed children's structures (see Table 38). Of the observed children who created structures, more than one-half made ones that touched the small clouds in the backdrop (60 percent), while less than one-half made ones that touched the big clouds (40 percent). Size of the children's structures did not differ by data collection conditions, demographics, or group composition.

TABLE 38

SIZE OF STRUCTURES IN PE

STRUCTURE SIZE (*n* = 50)	PE %
Touched small clouds (low)	60.0
Touched big clouds (high)	40.0

The fourth summary question asked data collectors to summarize the observed children's role in making the structures stand (see Table 39). Of the 40 observed children who created standing structures in the

photo-narrative experience, about three-quarters were somewhat responsible for the structure standing (78 percent) and most of the remaining children followed the directions of others (20 percent).

TABLE 39

ROLE OF OBSERVED CHILDREN IN BUILDING A FREE-STANDING STRUCTURE IN PE

ROLE (*n* = 40)	PE %
Somewhat responsible for the structure standing	77.5
Followed directions of others which made the structures stand	20.0
Primarily responsible for the structure standing	2.5

The fifth summary question asked data collectors to summarize how triangular and diagonal braces were used in the observed child's structure if his/her structure stood. Of 40 standing structures, about one-third used either triangular or diagonal braces to help the structure stand (33 percent used triangular braces and 30 percent used diagonal braces; 8 percent of structures used both) (see Tables 40 and 41).

TABLE 40

USE OF TRIANGULAR BRACES IN STANDING STRUCTURES IN PE

DESCRIPTION (*n* = 40)	PE %
Triangular braces used in structure, but only for decoration	35.0
Triangular braces used in structure to help it stand[1]	32.5
Triangular braces not used in structure	32.5

[1]In 22.5 % of structures, someone in the observed child's group was responsible for using the triangular braces; in 5.0 % of structures, the observed child followed the directions of others to use the triangular braces; and, in the remaining 5.0 % of structures, the observed child used triangular braces on his/her own without prompting from others.

TABLE 41

USE OF DIAGONAL BRACES IN STANDING STRUCTURES IN PE

DESCRIPTION (*n* = 40)	PE %
Diagonal braces not used in structure	50.0
Diagonal braces used in structure to help it stand[1]	30.0
Diagonal braces used in structure, but only for decoration	20.0

[1]In 17.5 % of structures, someone in the observed child's group was responsible for using the diagonal braces; in the remaining 12.5 % of structures, the observed child followed the directions of others to use the diagonal braces.

BEHAVIORS ASSOCIATED WITH NARRATIVE ACTIVITY IN PE

Nearly all observed children did the narrative activity with the adult(s) in their group (87 percent) (see Table 42). Of those who were accompanied by other children, three-quarters did the narrative activity with them (76 percent).

TABLE 42

HOW CHILD COMPLETES NARRATIVE ACTIVITY IN PE

DESCRIPTION (*n* = 53)	PE %[1]
Observed child does narrative activity with adult(s) in group (*n* = 53)	86.8
Observed child does narrative activity with other child(ren) in group (*n* = 37)	75.7
Observed child does narrative activity on his/her own (*n* = 53)	1.9

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

Nearly all adults contributed to the narrative one or more times (83 percent) (see Table 43). About three-quarters also coached the observed child on how to do the narrative activity (72 percent). Only one adult did not interact with the observed child during the narrative activity (2 percent).

When the role of adults during the narrative activity was examined by data collection conditions, demographics, and group composition, no statistically significant differences were found.

TABLE 43

ROLE OF ADULT DURING NARRATIVE ACTIVITY IN PE

INTERACTION (*n* = 53)	PE %[1]
Adult contributes to the narrative activity	83.0
Adult coaches child on how to do the narrative activity	71.7
Adult does not interact with observed child	1.9

[1]The total percentage exceeds 100 because observed children exhibited multiple behaviors over the observation period (i.e., observers marked whether behaviors happened at least once within five-minute intervals during the observation period).

PE SOCIAL INTERACTIONS

STAFF INTERACTIONS

One-quarter or fewer of observed children interacted with staff in the photo-narrative experience: 23 percent for logistics and 19 percent for content-related issues (see Table 44).

TABLE 44

STAFF INTERACTIONS IN PE

INTERACTION (*n* = 53)	PE %
Staff interaction: logistics	22.6
Staff interaction: content	18.9

At the end of the observation, data collectors were asked to summarize the adult-child interactions in the photo-narrative experience using multiple-choice responses (see Appendix A for the observation form). Adult males consistently interacted with the observed children during more than one-half of the observations (62 percent); females did so during more than one-third of the observations (39 percent) (see Table 45). During one-quarter of the observations, the female adults interacted little with the observed children (24 percent).

TABLE 45

OVERALL ROLE ADULTS PLAYED IN CHILDREN'S EXPERIENCES IN PE

ADULT FEMALE (*n* = 46)	PE %
Consistently coached, modeled, and/or helped child build	39.1
Interacted little with child	23.9
Periodically coached, modeled, and/or helped child build	19.6
Played disciplinary and logistical role	8.7
Once or twice coached, modeled, and/or helped child build	8.7
ADULT MALE (*n* = 34)	**PE %**
Consistently coached, modeled, and/or helped child build	61.8
Once or twice coached, modeled, and/or helped child build	11.8
Interacted little with child	8.8
Played disciplinary and logistical role	8.8
Periodically coached, modeled, and/or helped child build	8.8

AUXILIARY EXHIBITS

This section presents data from the four auxiliary exhibits in *Skyline*—Spin Browser exhibit, Triangle display/graphic, Can you Find Me? panels, and Stop the Wobble exhibit—that are adjacent to the large-scale building area.

During the summative evaluation of *Skyline*, 14 visitors were observed stopping at the auxiliary exhibits (see Table 46). The Spin Browser attracted the most visitors (*n*=10), followed by Stop the Wobble (*n*=4).

TABLE 46

STOPS MADE AT AUXILIARY EXHIBITS

EXHIBIT (*n* = 14)	*n*
Spin browser exhibit	10
Stop the wobble exhibit	4
Can you find me? panels	1
Triangle display/graphic	0

PRINCIPAL FINDINGS: IN-DEPTH CHILD INTERVIEWS

RK&A conducted 50 onsite interviews in July and August 2008 with visitors 5 to 10 years old visiting with family groups as they completed their building experience in the *Skyline* exhibition. Of interviewees, 26 were female (52 percent) and 24 were male (48 percent); interviewees' median age was 7 years. A total of 52 children were invited to participate in the evaluation but two declined, for a participation rate of 96 percent.

OVERALL EXPERIENCE

Overall, most interviewees spoke positively about their exhibition experience. About one-half used words like "fun," "great," or "cool" when describing their overall experience. Several interviewees said they thought the exhibition was fun because they could build and be creative (see the first quotation below). A few said the exhibition was fun because they could build with someone else (see the second quotation).

> I think it is fun to build houses because kids can learn to build and build [using] their imaginations and you can experiment. [female, 7 years]

> I think it was really fun that I got to build with my dad. [female, 6 years]

MOTIVATION FOR *SKYLINE* PARTICIPATION

About one-half of interviewees said they participated in the *Skyline* exhibition because they wanted to build something (see the first quotation below). Several interviewees said they participated because children in the exhibition looked like they were having fun (see the second quotation). A few said they participated because someone in their family wanted to do the activity (see the third quotation) and a few said they participated because they had used the exhibition before and had had fun (see the fourth quotation).

> Actually, I wanted to build. I saw this part earlier and knew I wanted to come here. [male, 8 years]

> I thought it [looked] like a fun exhibit because I saw kids having a great time and wanted to do it. [female, 6 years]

> My brother wanted to do it and I thought I would give it a chance. [female, 10 years]

> Last time I [came] here we had a lot of fun building the house and it falls down sometimes, but I wanted to come back and try it again. [male, 9 years]

FAVORITE ASPECTS

Slightly more than one-third of interviewees said they most liked building something, especially using tools and large-scale building materials (see the first two quotations). About one-third said they most enjoyed creating and having the chance to pretend play in the structure they built (see the third quotation). A few said they most liked successfully finishing their structure (see the fourth quotation), a few most liked building with someone (see the fifth quotation), and few did not know what they liked most.

> [I liked] building [something] and taking it down. [male, 6 years]

I [am] usually creative with Legos in my house, but [I like that] these [parts] are so much bigger. [male, 9 years]

You got to build a house and go in it and act like it is your own house. [male, 10 years]

[I liked] when [I] finished because you can see what it looks like. [male, 10 years]

[I liked that] there were two smaller boys who helped us build a house. [female, 10 years]

LEAST FAVORITE ASPECTS

About one-half of interviewees said there was nothing they did not like about the exhibition activity. About one-third said physically putting together materials, or knowing how to do so, was challenging (see the first quotation below). A few interviewees said they did not like running out of materials, and a few said working with others was challenging (e.g., disagreement among group members or sharing with other visitors) (see the second quotation).

Putting on those braces is hard. I did not like the part where you had to screw them in. [female, 8 years]

[I did not like] that people take things that other people [worked] so hard on. I would really hate it if someone tore [my structure] down. [female, 8 years]

GROUP COLLABORATION

Nearly all visitors collaborated with someone within or outside their visiting group to build their structure. Slightly less than one-half of interviewees said the best part about working with others to build was having input and help from other people to make their structure better in some way (e.g., taller) (see the first two quotations below). About one-quarter of interviewees said the best part about working with others was to share a fun experience (see the third quotation).

[I worked with] lots of people, people I asked to help. (What was the best part of working with them?) Probably that I get this thing I want to build done faster. [female, 8 years]

[I worked] with my two friends. We figured out what to do together and we worked together without screaming at each other. [female, 10 years]

We could do [the activity] with our family. It is fun doing it with our family. [female, 8 years]

When asked what was difficult about working with others to build their structure, about one-half of interviewees said there was nothing or they did not know whether there was anything difficult about working with others. Several said the most difficult thing was disagreeing over what to build and how to build it (see the first quotation below). A few said the most difficult aspect of working with others to build was sharing materials or communication (see the second quotation below).

[I worked with] my sister and dad. (What was the hardest part of working with them?) I could not do everything I wanted to do. I could not always decide what to make. [male, 10 years]

There are a lot of things going on with the house. If you tell someone on the other side [to do] something [and] they are holding [the structure], it might break. [male, 9 years]

USE OF STEM-BASED LANGUAGE AND CONCEPTS

When asked what they did to make their structure stand up, slightly more than one-half of interviewees used STEM-based language and concepts (see Appendix H) when describing their structure. For example, interviewees said they used diagonals, triangles, or a frame to brace their structure (see the first two quotations below). On the other hand, about one-quarter did not use STEM-based language or concepts, and instead said they used nuts and bolts to tighten their structure and help it stand up (see the third quotation) or used triangles, but not for support (see the fourth quotation).

> We put on these diagonals and it seemed to make it not topple. (How did you figure that out?) My mom told me but actually I could [have] figured it out. [male, 8 years]

> Well, the first time I used nothing. I thought it would stand up on its own, but it started tipping so I decided to use triangles. (How did you figure that out?) My grandpa brought the [triangles] over and it worked out [well]. [male, 10 years]

> (What did you do to make your structure stand up without falling over?) We used the nuts and screwdrivers to screw [them] on tightly. [female, 8 years]

> [We used triangles] for the roof. [They] looked like they could be a roof. [male, 5 years]

When asked how they knew how to make their structure stand without falling over, about one-third of interviewees said a parent or other adult told them what to use or they copied the ideas they observed in other structures (see the quotations above). Several interviewees said they used trial and error to make their building stand (e.g., added extra pieces to see if it would stop wobbling) (see the first two quotations below). A few said they knew something about how buildings stand and used that knowledge to build a stable structure (see the third quotation below).

> I put two [struts] at the bottom. (How did you figure that out?) I did not know how it would stand up so we just put them there. [male, 5 years]

> We put [some] of those [diagonal] bars right there to make it stand up. (How did you figure that out?) Well, at first it was kind of wobbly, so we thought to straighten it out a bit. [male, 6 years]

> We used the braces. (How did you figure that out?) We just knew [the braces] would make it stronger because [they] give it support. [male, 10 years]

PRINCIPAL FINDINGS: IN-DEPTH ADULT INTERVIEWS

RK&A conducted 50 onsite adult interviews in July and August 2008 with visitors 18 years and older visiting with family groups and at least one child aged 5 to 10 as they completed their building experience in the *Skyline* exhibition. Of interviewees, 31 were female (62 percent) and 19 were male (38 percent); interviewees' ages ranged from 22 to 62, with a median of 38. A total of 53 adults were invited to participate in the evaluation but three declined, for a refusal rate of 6 percent.

OVERALL EXPERIENCE

All but a couple of interviewees spoke positively about their exhibition experience. In fact, nearly three-quarters of interviewees described their experience with extreme enthusiasm and excitement—a few saying it was one of the best children's exhibitions they had ever used and a few others saying they repeatedly visit the exhibition. When asked to explain what they liked so much about the exhibition, most of these described their affinity for the exhibition in terms of how it promotes creativity, independence, free play, and imagination (see the first two quotations below). Some said what they liked best is the way the exhibition is designed—specifically that it is well organized, simple, and uses real tools (see the third and fourth quotations below). Some added that they also enjoyed the opportunity for a shared experience (see the last quotation below).

> I think it is more [about] her being able to think on her own to figure out exactly what she wants to make and making sure that she has her own creative mind. . . . So, it is great to see that she wants to do something [different]. [Male, 44 years]

> I thought [the exhibition] was really great. It gave the kids a chance to walk around and be creative and [to] work independently. That was really great. I was thinking it would make them use their imaginations. . . . She did this whole thing by herself. [Female, 22 years]

> [I like that] it is simple. There are a lot of different variations, but, there is only one size bolt and only one size nut that goes on it so they are not searching for which one goes with which. They all go together . . . no matter how long the bolt is. It is easier for them to just concentrate on their building than to be looking for the proper pieces. [Male, 37 years]

> [I like that the exhibition applies] to more than the 5-to-10-year-old age group. The best thing is for [the kids] to learn [how to use] the tools in a simplified manner. [They learn] what tools [to use], how they screw [and] which way, and [gain] confidence in building something that could actually look like something [real]. [Female, 42 years]

> [I liked] the team building that [the exhibition promotes]. When they are working with each other, it helps them to know that they cannot yell at each other to get things done. [Female, 22 years]

The other one-quarter of interviewees enjoyed the exhibition, but were less enthusiastic than the group described above. Notably, some of the less enthusiastic interviewees did not participate in the activity with their children. These interviewees were not as verbose in their explanations of why they liked the exhibition, with some expressing slight ambivalence, and others referring to it as educational or a good opportunity to spend time together. A few said they liked that the exhibition teaches real-world skills, such as using a screwdriver. Only two interviewees were generally negative about their experience, one

describing it as stressful and frustrating, and another saying she has little interest in building activities (nevertheless, both these parents said their children seemed to enjoy the experience).

All interviewees, regardless of their enthusiasm for the exhibition, were asked what they least liked about the experience. One-half said there was nothing they liked least. Of the other one-half, many said their only complaint was looking for, and sometimes not finding, the materials and resources they needed to build their structure. Other complaints were idiosyncratic and included having to watch small children, needing more instructions, and that the materials were too big.

GROUP COLLABORATION

More than three-quarters of adult interviewees said they had worked with their children to build a structure. Of these, nearly all found the experience extremely satisfying. About one-half of these said the most rewarding aspect of working together was watching their child accomplish a difficult task and produce a product s/he could be proud of (see the first two quotations below). These interviewees repeatedly mentioned "the smiles" on their children's faces as they finished their structures. Some of these explained that the accomplishment instilled confidence. The other approximately one-half said the most rewarding aspect of working together was spending quality time with their children (see the third and fourth quotations below). A few interviewees said they enjoyed watching their child have fun.

> I love to see the glow in [my son's] eyes when [he says,] 'I did it. Look at this. Mom, take my picture!' The self-earned success. [He] did it. It is [his]. [Female, 39 years]

> [I liked] being able to see [the children's] faces light up when we were done building and seeing their excitement [building] something that [started out as] just wood and [seeing] what we did [with it]. [Female, 37 years]

> Every minute that I spend with [my daughter] is rewarding for me. I get a lot of joy out of working with her. [Male, 44 years]

> [I liked] spending the time with [my son], knowing he is having a good time. I was honestly a bit worried about coming here today because he is ten years old and I had never been [to CCM] myself. I like this activity the best because it truly has kept him entertained the longest and he just seems genuinely happy to be here. [Female, 29 years]

Interviewees who worked with their child were asked to identify the most difficult aspect of group work; most said it was teamwork. Notably, none of these interviewees complained about teamwork, but rather described its challenges. More specifically, they said it was sometimes difficult to communicate with their young child, they sometimes had to negotiate roles or material use between children, they had difficulty relinquishing control when building the structure, and they had to adjust their work style to their child's particular pace (see the quotations below). Several parents said there was nothing difficult about working with their child.

> The adult has a certain picture in [his/her] mind of what they want to do so it is hard [to get] the kids to build exactly what you had in mind. You [have to] prod them along properly. [Male, 29 years]

> [It was challenging] when the boys had different ideas about what they wanted to do, and neither one of them wanted to compromise, [but] they eventually figured it out. [Male, 49 years]

[It was challenging] for me to lay back and let the [kids] actually [build]. I can see them trying to do something, and I could think of four other ways they could do it better, but. . . . They should learn how to do it themselves. [Female, 38 years]

We did not really run into any problems with the 'doing' [part] but, explaining things in simple enough terms for them to understand can be a challenge sometimes. [Male, 39 years]

BUILDING THE STRUCTURE

When asked to describe their structure, nearly one-half said they built a house, and nearly one-quarter said they built a tent. Some others described their structure generically without identifying it in any way (e.g., a "square structure"). Four interviewees said they built a skyscraper. Other structure descriptions were idiosyncratic and included "a cat mobile," "a castle," "a swing set," and "a ladder."

When asked how they decided to build what they built, one-quarter said they had no plan, but rather "just started putting pieces together." About one-quarter of interviewees said they had some kind of "vision" for their final product. Of these, some said the adult in the group decided what to build (usually owing to some previous or expert knowledge of building), and others said the child(ren) had decided. Several said they did not know how they decided what to build. A few said they watched other groups in the exhibition and copied what they were doing.

When asked how they figured out *how* to build their structure, one-third said they used trial and error (see the first two quotations below). Another one-third said they used previous knowledge, including some parents who identified themselves as an architect, engineer, or simply "handy" and experienced in putting things together (see the third and fourth quotations below). Of the remaining interviewees, some said they copied the structures of other visitors and some said they did not know how they figured out how to build.

(How did you or your child decide to build it this way?) It was really just trial and error. There were a few things that did not go together right, and [my son] changed his design in the end because he wanted to add some things to it. Because he wanted to add a heavier top to [the structure], we actually had to disassemble [the structure] a little bit and put it [back] together. The second layer had to be a little bit stronger. [Female, 53 years]

[Our structure] just kind of evolved. I knew that the bolts had to be tighter rather than looser obviously, and that there has to be a certain amount of support. I would say that is how [we decided to build], with [a] little background knowledge and then just trial and error. I see some things that I probably would not have done had I just been doing it myself, but that is what he did. So that would be one of those teaching moments [where] I [would] say 'Maybe it will be sturdier if we use this instead of this.' [Female, 29 years]

I thought [it] would be best [to build] through trial and error. [Male, 44 years]

I just had an inkling [our idea] would work. I have got more of an engineering background, so I put the reinforcing parts in. So, that was more dad's [idea] instead of the kids. [Male, 49 years]

When asked what they liked best about the way their structures turned out, interviewees provided a wide variety of answers. Some said they liked that their structure was "unique" or had "good form." Some

said they liked that their structure was sturdy and strong. A few said they liked finishing their project, a few said that their child had fun, and few said that they used teamwork. Several interviewees said they did not know what they liked best.

When asked what was most difficult about building the structure, one-quarter said nothing was difficult. Another one-quarter said stabilizing the structure was most difficult. Several each said aligning the parts so they would fit or finding the necessary materials and resources was most difficult. Some responses were idiosyncratic and included teamwork, having no plan, and the fact that the activity was too time-consuming.

Notably, adults who said they had not worked with their child to build the structure were the ones most likely to respond to the questions above by saying they did not know or by commenting generally.

UNDERSTANDING OF STEM-BASED CONCEPTS

When describing what they did to stabilize their structure so that it would stand without falling over, about three-quarters of interviewees used STEM-based language and concepts (see Appendix H). Most of these said they used diagonals or triangles, while others referred to cross-bracing or, more generally, to using a frame to brace the structure (see the quotations below). On the other hand, about one-quarter did not use STEM-based language or concepts, and instead said they used nuts and bolts to tighten their structure, that they could not make their structure stand, or that they did not know how they stabilized their structure.

> What did we do to make the structure stand up? We bolted the cross bars, then put two vertical end pieces, and then put braces in there. [Female, 62 years]
>
> [My son] used a triangular piece that was connected to one upright straight piece and one horizontal straight piece, so the triangular piece is supporting them and helping them stay in place. [Female, 39 years]
>
> The thing that is actually holding [our structure] up is the triangular braces. [They] are keeping it from wobbling back and forth. (And did you do anything to stabilize it, or anything else to stabilize it?) These bars probably help a little bit, but mostly the triangles are the ones that keep it from falling over. [Female, 22 years]
>
> We made our own triangles. We did not use the right angle ones, because we needed a different angle on [our structure]. So, just on the corners, if you look down there, each corner has got a reinforcing bar on it. [Male, 49 years]

Not all interviewees mentioned the use of triangles unprompted, but when asked specifically if they had used triangles and what they had used them for, more than one-half said they used triangles to stabilize their structure. Several interviewees said they used triangles, but for decoration. The other interviewees said they did not use triangles in their structure.

Again, adults who said they had not worked with their child to build the structure were the ones most likely to respond to the questions above by saying they did not know or by commenting generally. They were also more likely to say their child had *not* used a triangle to stabilize his/her structure.

EXHIBITION INFLUENCE

Interviewees who said they worked on the structure with their child were asked what, if anything, about the exhibition had helped them build their structure. One-quarter of these said the organization and simplicity of the exhibition's design had helped them. For instance, all the materials were easy to use and identify (see the first two quotations below). One-quarter said nothing about the exhibition had helped them or that they did not know whether anything had. Several interviewees said that other visitors' structures provided examples that they could model (see the third and fourth quotations). Several said the information about triangles had helped them (see the fifth quotation). A few said they thought the exhibition's open-ended design helped their child be creative, and one said a staff member had helped.

> I like the organization [of the exhibition] and that I could tell her to go to the red box and get some more screws [or] bolts. The way it was set up was nice. [Female, 62 years]

> I think the whole [exhibition] is structured in such a way that you can do things. (What aspect of the way that it is structured helped you?) [I like] the fact that everything is around you and you have got all the pieces and you [can] just put them together. Everything [is] so accessible. [Male, 42 years]

> There are all sorts of ideas around you because you can pick up something that somebody else left behind and start from there. So, that is a good starting point or you can start on your own too. (Where would you say the ideas came from?) When [my son] came in initially, he just saw another structure and started to disassemble that one and said, 'Let's build the Sears Tower.' [Female, 53 years]

> One thing [we saw] was another gentleman who obviously knew something about building. He was building with his very small child. [My son] saw that and started doing the same thing, imitating that gentleman. I think that was great and then, at the same time, when he spoke with that [gentleman], [he] was willing to talk to [my son], which was kind of cool too. [Female, 29 years]

> I suspect that some of the information that is around the exhibition was useful the first time that they were here learning about how triangle bracing is the strongest thing. [Male, 49 years]

PRINCIPAL FINDINGS: PHOTO-NARRATIVE EXPERIENCE

In July and August 2008, RK&A intercepted visitors 18 years and older visiting with family groups and at least one child between the ages of 5 to 10 as they completed their photo-narrative experience in the *Skyscraper Challenge* exhibit of the *Skyline* exhibition. The photo-narrative experience consists of visitor groups audio-recording their responses to the following six questions about their building experience:

- How did you figure out how to start building?
- What was each of you thinking as you built?
- What problems did you have as you built?
- How did your team try to solve these problems?
- What did each of you learn from making it?
- What do you think you'll remember from doing this?

Of 56 visitor groups intercepted, RK&A accessed photo-narrative experiences of 43 groups comprised of 68 adults and 78 children ages 5 to 10.[8] Seventy-eight visitors (38 adults and 40 children) were female, and 68 visitors (30 adults and 38 children) were male. A total of 56 visitors were invited to participate in the evaluation but eight declined, for a refusal rate of 14 percent.

VISITORS' AWARENESS OF BUILDING PROCESS

When asked how they figured out how to start building, one-third of visitors described using trial and error and teamwork to plan (see the first excerpt below). One-third of visitors said they chose to start their structure with a foundation and built "up" from there, sometimes specifying that they added walls or support bracing (see the second excerpt). Several said they decided to build a specific structure (e.g. a(n) house or apartment) or decided to create as they built (see the third quotation). A few visitors said they looked at the other buildings to get ideas about how to build their own structure (see the fourth excerpt).

> [We] just picked some braces. *And we started building. [adult, child]

> [We] first had to build from the ground up. A good foundation makes a good building. *So we added the rod-like pieces and we made a foundation. [adult, child]

> We thought we would just use our imagination. [adult]

> We looked at other buildings. *And [they] usually first made a base. [adult, child]

When asked what they were thinking as they built their structure, many visitors said they were thinking about how to build their structure taller, more quickly, or more stable (see the first two quotations below). About one-quarter of visitors said they were thinking that building a structure is difficult or that

[8] The photo-narrative experiences of 13 visitor groups were ineligible owing to audio quality, a language being spoken other than English and/or the absence of *any* children within the exhibition's target age range of 5 to 10.

one needs a team or plan to build well (see the third quotation below). A few visitors said they were thinking about how they enjoyed the experience (see the fourth quotation below).

> We were thinking about making sure there were enough braces to give [our building] support. [adult]
>
> I was thinking about how we could make the structure more stable and build it higher. [child]
>
> [I was thinking that] we should [try] and make it to the clouds and that it is really hard and you need to work together to make it happen. [child]
>
> I was thinking about how much fun it was to put the bolts inside the holes and then to put the nuts down and tighten them. [adult]

PROBLEM-SOLVING STRATEGIES

When asked what problems they had as they built, about one-third of visitors said they had difficulty choosing which pieces to use and how to use them (see the first excerpt below), another one-third said they had trouble making their building stable (see the second excerpt), and another one-third said they did not have enough pieces to work with or enough time to complete their structure (see the third excerpt). A few visitors said they had difficulty communicating with their group or planning how they would build their structure (see the fourth quotation).

> The triangle pieces would not fit. *I kept putting the nuts on the wrong way and we ran out of the long braces. [child, adult]
>
> [Our building] kept on wobbling and the way we built it, you can kind of move it up and down. *[That] is true. [The building] was not braced correctly so it could still wobble and move up and down. [child, adult]
>
> [There] were not enough [materials] to create our masterpiece. *[Also,] we did not have enough time. [adult, child]
>
> (What problems did you have as you built?) We all had different ideas. [adult]

When asked how their team tried to solve their building problems, slightly more than one-half of visitors said they used teamwork and brainstormed how to fasten things together (see the first quotation below). A few visitors said they sought help either from another group, their parents or a staff member (see the second excerpt). A few said they used trial and error or critical thinking (see the third quotation below), and a few said they attached more bracing to their structure (see the fourth excerpt below).

> [When] we were building, it was very hard because sometimes [the structure] was falling over. (How did your team try to solve these problems?) We borrowed pieces from a neighbor and we worked together holding on to the pieces and we put it together as a team. It worked much better that way. [adult]
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> We had some problems because we tried to build [our structure] straight up. (How did your team try to solve these problems?) *We talked about it together and we said 'how about if we do this, how about if we do that' [and] we tried to look at what other people had done with their

skyscrapers to get ideas. . . . We figured out how to brace [the structure] so it would stand up by itself. [child, adult]

We used trial and error. We talked to each other and [that] helped [us] figure out how to do it, and we listened when someone said 'This way works, try this.' [adult]

[We had problems] making [our structure] sturdy. (How did your team try to solve these problems?) *[We used] cross-supports and braces along the base. [child, adult]

VISITOR LEARNING

When asked what they learned or would remember from making their building, slightly more than one-half of visitors said they learned or would remember that teamwork is necessary for building (see the first excerpt below), that communicating with your team can be difficult (see the second quotation), or that working with others to build something is fun (see the third quotation). About one-third said they learned or would remember how to attach nuts and bolts together (see the fourth quotation) or that one must make a building stable (see the fifth quotation). Several said they learned or would remember that building a stable structure is difficult (see the sixth quotation).

We [learned] that, if we work together, we will make a great building. . . . *Right, and we learned that if we work[ed] together, we could make some interesting things [and] we could make [our building] happen. [adult, child]

[We] learned that it is really hard to work as a team and [to] know what to do together, so it was really hard that way. [child]

I learned that it is really fun to come out and spend time [building] with my granddaughter who has a great imagination. [adult]

I learned from others and from my daddy [how] to turn the bolts. [child]

I learned that you should first make [your building] stable and then try to make it go higher and higher. [child]

It is really hard to build a building that does not jiggle around like wiggly Jell-O. [child]

STEM-BASED LANGUAGE AND CONCEPTS

In response to questions overall, slightly more than one-half of visitor groups used STEM-based language or concepts (see Appendix H) when talking about their building experience. More specifically, slightly more than one-third identified and described at least one engineering solution (e.g., framing or cross-bracing) that helps a building stand up (see the first quotation below). About one-third identified one or more physical properties of basic building materials (see the second quotation). A couple of visitors identified and described the triangle as an important structural element (see the third excerpt below).

You always [have to] build a foundation and, from the foundation, you are going to build the walls, and from the walls, you build the next wall. If you do not do the foundation, the rest of it falls to a heap, so you have to do the foundation first. [adult]

Building was wonderful. Look at all the colors that we used, and the shapes. [adult]

We wanted [our structure] to be stable, so how did we make it stable? *We used a lot of triangles. [adult, child]

APPENDICES

REMOVED FOR PROPRIETARY PURPOSES