



Liberty Science Center *Skyscraper!* Exhibition: Summative Evaluation Report

Prepared by:

Kerry Bronnenkant, M.Ed.
Cláudia Figueiredo, Ph.D.

Edited by:

Martin Storksdieck, Ph.D. and Jessica Luke, M.A.

Institute for Learning Innovation
Edgewater, MD

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EXECUTIVE SUMMARY

Liberty Science Center (LSC) received National Science Foundation (NSF) funding to develop, install and evaluate a 12,800-square foot, two-story permanent exhibition about skyscrapers. *Skyscraper!* is meant to showcase the architectural design and engineering, physics, and urban-related environmental science of skyscrapers.

The Institute for Learning Innovation (ILI), a Maryland-based research and evaluation organization that focuses on lifelong learning in informal or free-choice settings, was contracted to conduct the summative exhibition evaluation. The purpose of the summative evaluation was to assess the impact of skyscraper on visitor learning and visitor experiences; specifically, the summative evaluation aims to provide LSC with information on visitors' experiences within the exhibition, and the degree to which learning outcomes relating to its two major goals and learning outcomes have been achieved.

ILI used a mixed-methods approach to provide a rich, detailed picture of the visitor's experience within the *Skyscraper!* exhibition. Exit interviews for the entire exhibition that explored visitor perception, satisfaction, learning and suggestions for improvements were complemented by structured observations (timing and tracking) of visitor behavior within *Skyscraper!* Data from the entire exhibition experience were supplemented with focused observations and exit interviews of four key components of the exhibition: Energy Comparison, Shake Table, Schedule and World Trade Center Steel. Three overarching evaluative questions informed the study:

Evaluation Question 1: What did visitors do within the *Skyscraper!* exhibition?

Timing and tracking data as well as structured observation suggest that visitors to *Skyscraper!* were exposed to a variety of experiences that can lead to enjoyment and learning. Visitors spent considerably more time in the exhibition than in other, comparable science center exhibitions at other venues with a similar number of exhibit elements (Serrell, 1998). However, visitors spent less time than expected in *Skyscraper!* when measured by the floor space (a less concise standard than number of exhibition elements). Timing and tracking data suggest that visitors attended, on average, about 20% or seven of the available 39 exhibits and exhibit components, and that they engaged, on average, relatively strongly with those exhibits and exhibit elements. There was a strong overlap between popular and engaging exhibits in *Skyscraper!* Behavioral data suggest that visitors were exposed to some of the key exhibits and interacted considerably with others, providing visitors with the exposure needed to gain some understanding from their visit to *Skyscraper!* Four exhibits in *Skyscraper!* had strong holding power, engaged visitors moderately or extensively, and spurred relatively high levels of social interactions.

Evaluation Question 2. What did visitors take away from *Skyscraper!*?

Exit interviews with visitors to the exhibition and users of four key exhibits suggest that about one-fifth to one-quarter of visitors may have learned new material, mostly at the level of awareness and basic knowledge, and that about a third of visitors were able to access and reinforce latent awareness and knowledge. *Skyscraper!* was particularly

successful in creating awareness in visitors of the technological and organizational challenges in building skyscrapers. The exhibition may have created new awareness about the professional field involved in designing and building skyscrapers, issues faced by engineers when building skyscrapers, and awareness about positive and negative environmental issues associated with skyscrapers in about one-fifth to one-quarter of respondents; another third of respondents were reminded of something from their prior knowledge. The majority of respondents already arrived at *Skyscraper!* with an awareness and knowledge of these issues.

Evaluation Question 3. What was the appeal of the exhibition and of specific exhibits, and how satisfied were visitors with their experience?

Skyscraper! was well received by visitors. It was rated positively by about 60% of respondents, and rated negatively by about 23%. The average visitor rating for the exhibition was similar to that for other exhibitions. Visitors to *Skyscraper!* would have liked more interactive and hands-on experiences. A few design changes may have the potential to increase visitor satisfaction and learning, including advance organizers and orientations at key locations within the exhibition space, improved signage to guide visitors to currently underutilized areas of the exhibition, and improved signage or video footage for interactives that require staff facilitation.

Overall, the results of this summative evaluation suggest that *Skyscraper!* was successful on a variety of measures. Visitor critique centered mostly on a perceived lack of hands-on or interactive experiences.

INTRODUCTION

Liberty Science Center (LSC), located in New Jersey across the Hudson River from the former World Trade Center, received National Science Foundation (NSF) funding to develop, install and evaluate a 12,800 square foot, two-story permanent exhibition about skyscrapers. *Skyscraper!* is meant to showcase the architectural design and engineering, physics, and urban-related environmental science of skyscrapers. The exhibition is organized around two basic learning goals and seven specific learning outcomes:

Goal 1: Designing, building and maintaining skyscrapers requires knowledge of science, engineering, technology and mathematics.

1. Visitors will describe important processes and technologies used to design and build tall buildings
2. Visitors will describe or map out major components of tall buildings (foundations, columns, capitals, load bearing beams, hanging walls, etc) and/or construction sequences
3. Visitors will identify common building materials and give reasons as to why these materials are effective
4. Visitors will list some systems and safety features that allow people to use and inhabit skyscrapers

Goal 2: Skyscrapers have a profound influence on our culture and on the natural world.

5. Visitors will address environmental effects resulting from the concentration of large numbers of people
6. Visitors will identify environmental issues that surround skyscrapers
7. Visitors will talk about ways that skyscrapers affect quality of life in the city

The Institute for Learning Innovation (ILI), a Maryland-based research and evaluation organization that focuses on lifelong learning in informal or free-choice settings, was contracted to conduct the summative exhibition evaluation. The purpose of the summative evaluation was to assess the impact of *Skyscraper!* on visitor learning and visitor experiences; specifically, the summative evaluation aims to provide LSC with information on visitors' experiences within the exhibition, and the degree to which learning outcomes relating to the two major goals and learning outcomes have been achieved.

METHODS AND SAMPLES

Evaluation Design

The Liberty Science Center summative evaluation used a mixed-methods approach to provide a rich, detailed picture of the visitor's experience within the *Skyscraper!* exhibition. Exit interviews for the entire exhibition that explored visitor perception, satisfaction, learning and suggestions for improvements were complemented by structured observations of visitor behavior within *Skyscraper!* Data from the entire exhibition experience were supplemented with focused observations and exit interviews of four key components within the exhibition. Three overarching evaluative questions informed the study, each supported by more detailed instrument questions:

1. What did visitors do within the *Skyscraper!* exhibition?

This question yielded information on visitor behavior and use of *Skyscraper!* that documented the exposure of visitors to potential learning experiences.

- a) How long did visitors stay in *Skyscraper!*?
- b) What exhibits did visitors attend to and how did they interact with them within *Skyscraper!*?

2. What did visitors take away from *Skyscraper!*?

This question about visitor learning as a result of experiencing the exhibition was assessed in a multi-step approach that allowed visitors to explore their own knowledge and perceptions from a broad perspective down to specific content.

- a) What do visitors think about skyscrapers? [This open-ended question explored visitors' overall awareness and ability to connect the exhibition to their lives]
- b) What Big Idea(s) do visitors take away from visiting Skyscrapers!?! [Answers to this question documented visitors' ability to recognize and explain major overarching content themes of the exhibition]
- c) Do visitors leave the exhibition with an understanding of what training is needed to build skyscrapers? [This question served as an indicator for how well the exhibition was able to convey specific content to visitors]
- d) Do visitors understand the issues that face engineers in building skyscrapers? [This question served as an indicator for how well the exhibition was able to convey specific content to visitors]
- e) What effects do skyscrapers have on the environment? [This question served as an indicator for how well the exhibition was able to convey specific content to visitors]

3. What was the appeal of the exhibition and of specific exhibits and how satisfied were visitors with their experience?

Visitors' satisfaction with the exhibition and visitors' sense of appeal for specific exhibition elements was used to provide suggestions for improving the overall visitor experience.

Sampling

Data for this evaluation were collected from June to August 2008 using three methods: timing and tracking, exit interviews, and structured observations/interviews. Instruments and procedures were developed by ILI researchers and data were collected and entered by LSC staff. LSC staff members were given a one-day training session by ILI researchers to ensure that data were gathered in a consistent and systematic way. Data were entered into Excel spreadsheets and transferred for analysis into SPSS (a statistical analysis software program). Open-ended questions were coded based on themes that emerged from the data. The resulting samples for each method are outlined in Table 1.

Table 1: Summary of methods, sample sizes, and data collection period

Method	Sample Size	Time Period
Timing and Tracking	50	June 23 – 30, 2008
Exit Interviews	75	June 24 – August 05, 2008
Specific Component Observation/ Interviews	95	June 24 – August 05, 2008

Timing and Tracking

Timing and tracking is a specific version of unobtrusive, structured observations for behavioral data in which data collectors follow an individual throughout the exhibition, noting the time spent in the exhibition, levels of engagement with individual exhibits, whether individual exhibits were attended to, and social interactions that resulted from engaging with the exhibition.

A total of 50 groups were randomly selected for the timing and tracking portion of the study. A detailed map of the exhibition floor with all exhibition components was used to record visitors' movements and behaviors within the exhibition (see Figure 10 in Appendix 1), as well as demographic data such as apparent sex of the individual and the group type within which the visit occurred (adults only, family groups, individual). Individuals for tracking were chosen at random: the first person (as individual or member of a group) who crossed an imaginary line after data collectors were ready to track was selected to be followed through the exhibition.

Data from the timing and tracking study revealed the average frequency with which specific exhibits were visited (also referred to as "hit rates" since it records the percentage of visitors who attend to a specific exhibit – or "hit" it – while providing information on the popularity or attracting power of exhibits). Hit rates (or attracting power) are then contrasted to engagement scores, or the degree to which visitors made use of an exhibit once they chose to attend to it.

Engagement with exhibits was measured using a 4-point scale, where:

- 1 = **no engagement:** Visitor walks by but pays no to almost no attention.
- 2 = **cursor interaction:** Visitor stops, glances or in other ways pays some, but little attention, to the exhibit. This may include some level of interaction that does not seem to be related to exhibit message.

- 3 = **moderate interaction:** Visitor engages with less than half the exhibit, or seems to be doing an activity as intended but does not complete it fully, or watches part of a video, or completes part of a computer exercise, etc.
- 4 = **extensive interaction:** Visitor seems to read entire panel text and looks at object; completes computer exercise; watches entire or almost entire video, keenly observes an object; interacts and shows visible signs of mental and not just physical engagement.

The data for timing and tracking is presented in three so-called “heat maps” - visual displays of data using the exhibition floor maps and color coding for hit rates, engagement, and social interaction (Figures 3 through 5). Tabulated data used to create the maps are summarized in Table 22, Appendix 4.

Exit Interviews

In order to assess whether the exhibition achieved its overarching goals, 75 semi-structured interviews were conducted with adult visitors upon leaving the exhibition (see Appendix 2 for protocol and questionnaire). Interviewers probed visitors for their general associations with the term and concept of skyscrapers; their understanding of the exhibition’s Big Ideas; and their understanding of three specific knowledge indicators (training needs, engineering challenges, and environmental impacts). The interviewers also probed visitors for their reaction to the exhibition (what they most enjoyed and least enjoyed about the exhibition).

Specific Component Observation and Interviews

Liberty Science Center staff identified four key exhibition components that best helped to convey the learning outcomes for the exhibition: the Shake Table, the Schedule, the World Trade Center Steel and the Energy Consumption exhibit. In order to assess whether those four exhibit components achieved their overarching goals with visitors, specific component observations and interviews were conducted with 95 visitors. Visitors were observed utilizing the exhibit and then interviewed using a semi-structured interview (see Appendix 3 for interview protocol and questionnaire).

RESULTS AND DISCUSSION

This section is structured to report results for the three main evaluation questions:

1. What did visitors do within the *Skyscraper!* exhibition? [Behavioral measures for engagement]
2. What did visitors take away from *Skyscraper!*? [Learning as a result of experiencing the exhibition]
3. What was the appeal of the exhibition and of specific exhibits and how satisfied were visitors with their experience? [Visitor satisfaction and exhibition appeal]

1. WHAT DID VISITORS DO WITHIN THE SKYSCRAPER! EXHIBITION?

This section describes visitors' behavior in Skyscraper and compares the results to similar data obtained in a national study conducted under the leadership of Beverly Serrell (1998).

How did visitors use Skyscraper!?

Time spent in *Skyscraper!* [Holding Power]

About 60% of those tracked were females and the majority (79%) were visiting the exhibition in groups that had at least one child. On average, visitors spent 23 minutes visiting the entire exhibition (see Table 2). Time spent in the exhibition ranged from 3 to 77 minutes; the median time spent was 17 minutes, the most common time (mode) was 13 minutes. The average time was skewed by a few visitors who spent an extraordinary amount of time in the exhibition (see Table 2 for an overview). Serrell (1998) found in a national comparative study that visitors on average spent 11.5 minutes in science center exhibitions that contained an average of 32 exhibition elements (compared to 38 in *Skyscraper!*) and distributed across an average gallery space of 3,900 square feet (compared to 12,800 square feet for *Skyscraper!*)¹.

¹ Serrell, B. (1998). *Paying Attention: Visitors and Museum Exhibitions*. [Professional Practice Series (Adams, R., Ed.)]. Washington, D.C.: American Association of Museums.

Table 2: Summary of time spent in the exhibition

Area	n	Median (min)	Mode (min)	Mean (min)	Standard Deviation	Min (min)	Max (min)
Overall	50	17	13	22.7	15.3	3	77
<i>Sex^a</i>							
Female	19	21	12 ^a	23.5	14.9	3	63
Male	11	17	13 ^a	20.4	11.6	6	47
<i>Group Type^a</i>							
Adults Only	9	14	13	17.4	6.5	11	30
Adults with Children	34	17.5	12	23.5	16.9	3	77
<i>Crowdedness Level^a</i>							
Empty	8	17.5	12 ^b	19.3	7.3	12	33
Moderately visited	35	17	13 ^b	22.0	15.1	3	77
Crowded	5	16	11 ^a	23.4	19.5	11	58

^a Missing data: number may not add up to n=50. Differences within each category were not significant for p<0.05 in Mann-Whitney U and Kruskal-Wallis tests. ^b Multiple modes exist. The smallest value is shown.

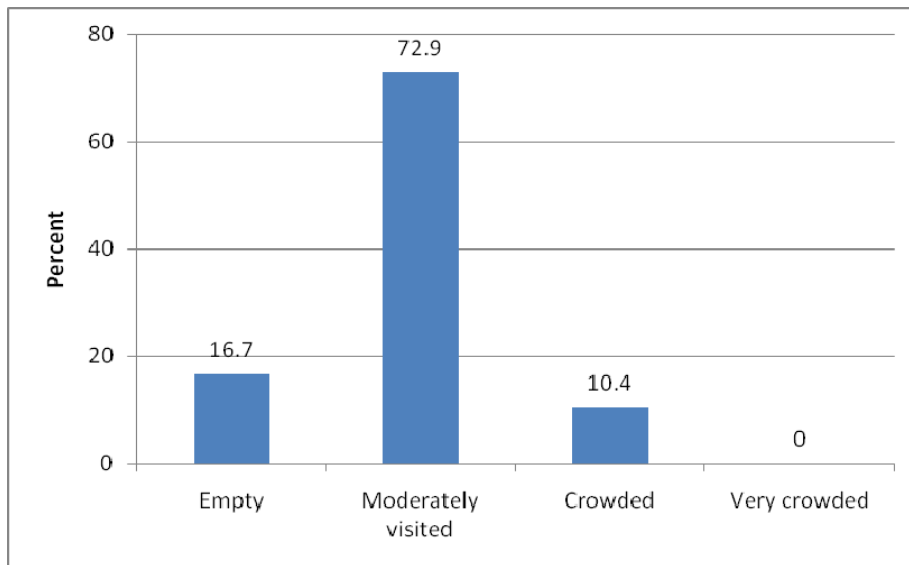
⇒ Timing and tracking data suggest that visitors spent considerably more time in the exhibition than in comparable science center exhibitions elsewhere with a similar number of exhibition elements. However, visitors spent less time than expected in *Skyscraper!* when measured by the floor space (a less concise standard than number of elements).

Exhibition stay time can be affected by crowdedness (Serrell 1998). A visual measure of crowdedness was recorded during the start of each visitor observation [it is acknowledged that crowdedness can change over the course of about 23 minutes, although this change, on average, is negligible].

During 73% of the observations, the exhibition was moderately visited, meaning that it was comfortably filled with visitors, with pleasant noise level, and that the exhibits were accessible and with little wait time for interactives. At no time during the data collection process was the exhibition considered very crowded (See Figure 1).

⇒ Crowding did not likely influence visitors' ability to engage with exhibits and thus was not likely to influence the overall time visitors spent in *Skyscraper!*

Figure 1: Crowdedness level of the exhibition during timing and tracking



Attentiveness to *Skyscraper!* exhibits

Visitors stopped on average at seven of the 38 exhibits observed (see Table 3).² Groups with children visited significantly fewer exhibits than those comprised only of adults.³

Table 3: Overall number of exhibits where visitors stopped during their visit

Area	n	Median	Mode	Mean	Standard Deviation	Min	Max
Overall	50	7	8	6.9	4.4	0	18
<i>Sex^a</i>							
Female	19	6	6	7.2	3.9	0	17
Male	17	8	8 ^b	8.4	4.8	1	18
<i>Group Type^a</i>							
Adults Only	9	9	8 ^b	9.7 ^c	2.55	5	13
Adults with Children	34	6	6	5.7	4.0	0	17
<i>Crowdedness Level^a</i>							
Empty	8	7	8 ^b	5.8	3.4	0	9
Moderately visited	35	7	0 ^b	6.8	4.7	0	18
Crowded	5	8	8	7.4	2.2	4	10

^a Missing data: number may not add up to n=50. ^b Multiple modes exist. The smallest value is shown. ^c Groups of adults with children visited significantly fewer exhibits than those without children (Mann-Whitney=58.00, p<0.05).

² Some of the exhibits within Skyscraper, such as Curtain Wall (SK3.35), Walking the Steel (SK3.31), and Wind Tunnel (SK2.09) were highly hands-on, requiring staff facilitation and were therefore only scheduled on a limited basis. Some of the data collection occurred during times when no staff facilitation at those exhibits was available. Data for these three exhibits need to be interpreted with caution.

³ Mann-Whitney=58.00, p<0.05

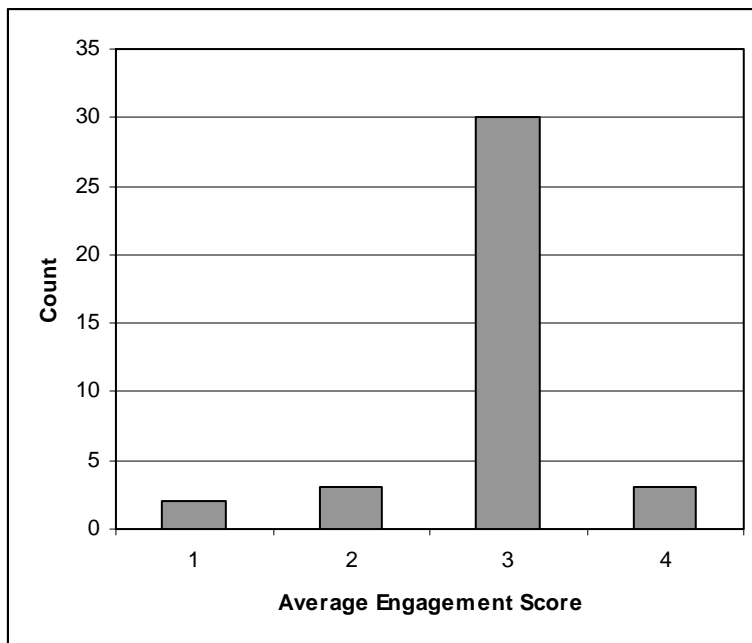
⇒ Timing and Tracking data suggest that visitors attended, on average, about 20% of the available exhibits and exhibition elements.

Visitor engagement with individual exhibits

Engagement with exhibits was measured using in a 4-point scale, where 1 equals minimal, 2 equals cursory, 3 equals moderate, and 4 equals extensive or full engagement. Means of engagement scores ranged from 1.3 to 3.6, with an average mean value of 2.8 (SD=0.5). When attended to by visitors, the vast majority of exhibits received average engagement scores of 2.5-3.4 (category 3). Only three exhibits had average scores below 2.5.

⇒ While visitors attended to, on average, seven out of 39 exhibits or exhibit elements, they showed relatively strong average engagement for those exhibits they attended to.

Figure 2: Frequency distribution of average engagement scores for 38 exhibits



Note: Scale anchors served as midpoints for the four frequency distribution categories. E.g., a mean engagement score for an exhibit between 2.5 and 3.4 would lead to the classification of “3” in the above frequency distribution table.

Table 4, below, lists the 10 exhibits that were visited most frequently. All of these exhibits also received relatively high engagement scores; half of them received scores of 3.0 or higher. Two of the four key exhibits, World Trade Center Steel and The Schedule were among the ten most visited exhibits.

Table 4: Summary of tracking data – 10 most popular exhibits

	Frequency of Stops		Engagement Score (1-4) mean
	n	%	
Designing for a City	21	42	2.7
Crane Model	20	40	3.4
Frame Forces	19	38	2.8
Skyscraper Culture	18	36	2.8
Excavating Tools	16	32	3.6
World Trade Center Steel	16	32	3.3
Skyscraper Lineup	15	30	3.3
Wind Tunnel	15	30	3.0
Skyline of Greats – The Models	15	30	2.7
The Schedule	15	30	2.6

Table 5 lists the 10 most engaging exhibits in *Skyscraper!*, those with average engagement scores of 3.2 or higher. Four of these 10 exhibits had hit rates of 30% or higher, indicating that they were also fairly popular among *Skyscraper!* visitors. While three of the high engagement exhibits were visited less frequently than the average exhibit in *Skyscraper!*, there is a strong overlap between popular and engaging exhibits. In addition, two of the four key exhibits, “Shake Table” and “World Trade Center Steel”, were among the most highly engaging exhibits. “Skyscraper as Home” and “Beam Construction” were the only two exhibits with very low average engagement scores (1.3).

Table 5: Summary of tracking data – 10 most engaging exhibits

	Frequency of Stops		Engagement Score (1-4) mean
	n	%	
Excavating Tools	16	32	3.6
Foundation Testing	8	16	3.6
Xtreme Wear	11	22	3.5
Shake Table	10	20	3.4
Crane Model	20	40	3.4
On Top of the World	5	10	3.4
Skyscraper Lineup	15	30	3.3
Fond Memories	3	6	3.3
World Trade Center Steel	16	32	3.3
Crane Simulator	10	20	3.2

⇒ There was a strong overlap between popular and engaging exhibits in *Skyscraper!* Behavioral data suggest that visitors were exposed to some of the key exhibits and interacted considerably with some others, providing visitors with the exposure needed to gain some understanding from their visit to *Skyscraper!*

Table 6 lists the 12 exhibits (a third of the total exhibits featured in *Skyscraper!*) that were visited by fewer than 10% of the Timing and Tracking sample visitors.

Table 6: Summary of tracking data – less visited exhibits

	Frequency of Stops		Engagement Score (1-4) mean
	n	%	
Mechanical Systems	4	8.0	2.3
Energy Comparison	4	8.0	2.3
Green Machines	4	8.0	2.8
Beam Construction	3	6.0	1.3
Elevator Etiquette	3	6.0	3.0
Skyscrapers as Homes	3	6.0	1.3
Cleaning Up	3	6.0	3.0
Mix & Match Towers	3	6.0	2.3
Fond Memories	3	6.0	3.3
Safety Monitoring	2	4.0	2.5
Birds in the City	2	4.0	2.5
Material Table	1	2.0	3.0

Social Interactions at *Skyscraper!* exhibits

On average, visitors had social interactions at about half the exhibits they attended to. Levels of social interaction were not influenced by sex, group type or crowdedness levels. Table 7 features exhibits where more than half the engagements involved social interactions, and therefore opportunities for family and social learning.

Table 7: Summary of tracking data – exhibits with most social interaction

	Frequency of Stops		Social Interaction	
	n	%	n	%
Skyscraper Culture	18	36.0	10	20.0
Wind Tunnel	15	30.0	8	16.0
Shake Table	10	20.0	6	12.0
Excavating Tools	16	32.0	9	18.0
Foundation Testing	8	16.0	5	10.0
On Top of the World	5	10.0	3	6.0
Walking the Steel	7	14.0	4	8.0
Energy Comparison	4	8.0	3	6.0
Elevator Etiquette	3	6.0	2	4.0

Overview of visitor behavior in *Skyscraper!* – Heat Maps

The following heat maps (Figures 3-5) provide a visual summary of the timing and tracking data. A key to exhibit numbers is provided in Table 8 and each figure is described in more detail below.

Figure 3 - Stops at exhibition components

The 38 exhibits observed were visited by at least one and as many as 21 visitors. Heat maps were created by categorizing exhibits into *hot* (when 32% or more of visitors stopped); *warm* (12-31% of visitors stopped); and *cool* (less than 11% of visitors stopped). The categories of *hot*, *warm*, and *cool* were based in the distribution of the responses: exhibits that were categorized as *hot* fell into the 4th quartile, *warm* ones into the 2nd and 3rd quartiles, and *cool* ones into the 1st quartile. Six exhibits were considered *hot*, 20 were considered *warm*, and 12 were considered *cool*. The hot exhibits began upon entrance and continued in along the left side of the exhibition towards the Crane Simulator. The warm and cool exhibits were spread out throughout the exhibition space.

Figure 4 - Level of engagement with exhibition components

Engagement with exhibits was measured using a 4-point scale, as outlined earlier. Exhibits were again categorized based on their average engagement scores into the 1st quartile *hot* (mean=3.3 and above), the 2nd and 3rd quartile *warm* (mean=1.9 to 3.2) and the 4th quartile *cool* (mean=1.8 and below). Most exhibits were in the *warm* category (n=27), while two were considered *cool*, and nine were classified as *hot*. With the exception of the World Trade Steel (SK3.18), all *hot* exhibits were exhibits that allowed for hands-on interaction.

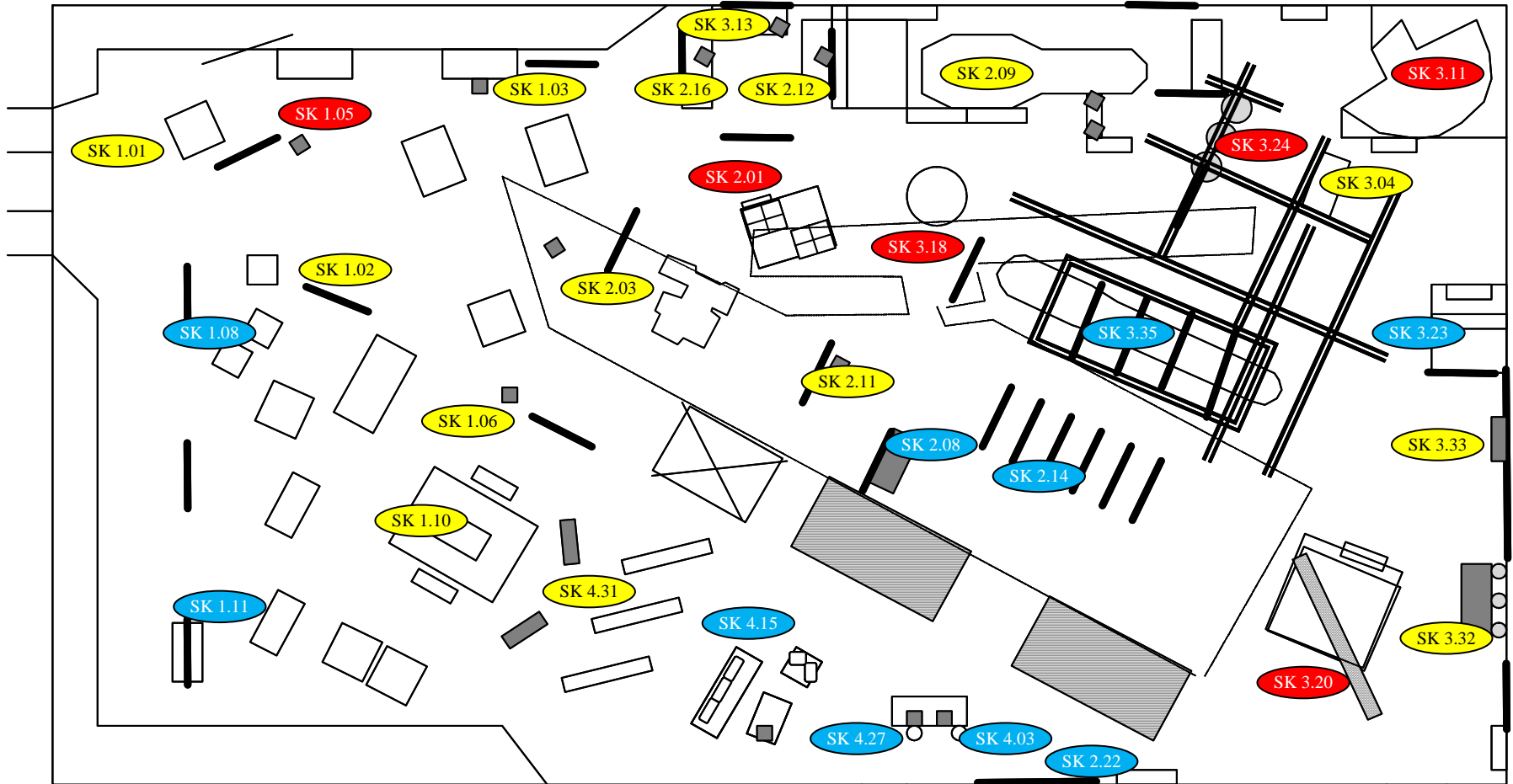
Figure 5 - Social interaction at exhibition components

Social interaction heat map included the categories *hot* (15% or more of visitors had social interactions at the exhibit), *warm* (5 to 14% of visitors had social interactions at the exhibit) and *cool* (4% and below had social interactions). Four exhibits were in the *hot* category, 21 were *warm*, and 13 were *cool*. *Hot* exhibits tended to be those of a more interactive, hands-on nature. Social interaction could only be noted at exhibits that had visitors attended to; components that had little or no visitation also tended to have low social interaction and appeared *cool*.

Table 8: Key to exhibits name and numbers

Exhibit #	Exhibit Name	Exhibit #	Exhibit Name	Exhibit #	Exhibit Name
SK.1.01	Skyline of Greats – The Models	SK.2.12	Shake Table	SK.3.32	Xtreme Wear
SK.1.02	The First Skyscraper	SK.2.14	Mechanical Systems	SK.3.33	The Schedule
SK.1.03	On the Horizon	SK.2.16	Elevator Mechanics	SK.3.35	Curtain Wall
SK.1.05	Skyscraper Culture	SK.2.22	Safety Monitoring	SK.4.03	Elevator Etiquette
SK.1.06	Skyscraper Lineup	SK.3.04	Geology	SK.4.15	Skyscrapers as Homes
SK.1.08	Mix & Match Towers	SK.3.11	Excavating Tools	SK.4.16	Cleaning Up
SK.1.10	WTC Remembered	SK.3.13	Foundation Testing	SK.4.25	Heat Island Effect
SK.1.11	Fond Memories	SK.3.18	World Trade Center Steel	SK.4.26	Birds in the City
SK.2.01	Designing for a City	SK.3.20	Crane Model	SK.4.27	Energy Comparison
SK.2.03	Architect & Engineer	SK.3.21	Crane Simulator	SK.4.29	On Top of the World
SK.2.08	Material Table	SK.3.23	Beam Construction	SK.4.30	Green Machines
SK.2.09	Wind Tunnel	SK.3.24	Frame Forces	SK.4.31	Visions of the Future
SK.2.11	Wild Forces Simulator	SK.3.31	Walking the Steel		

Figure 3: Heat Map for stops at exhibition components

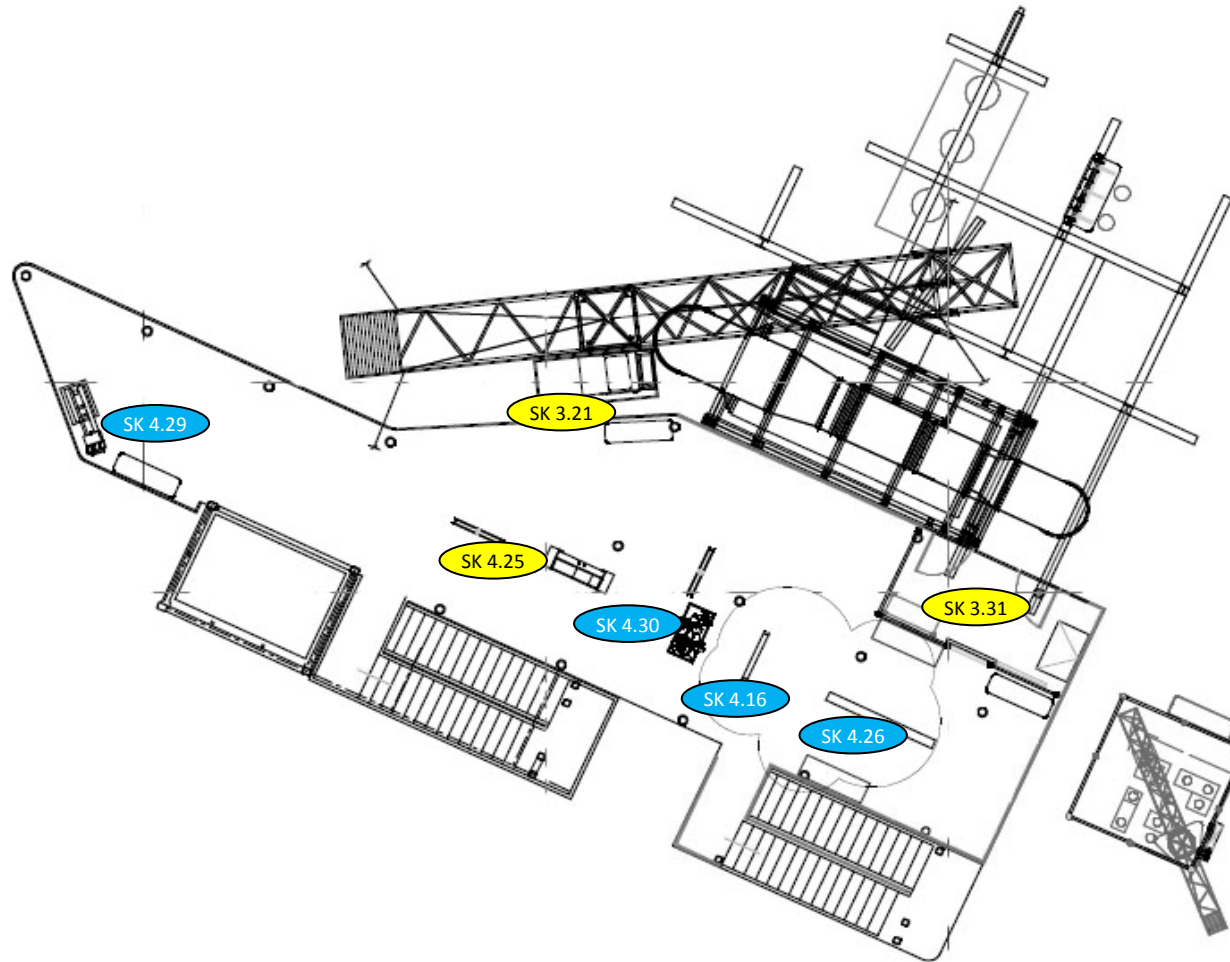


Key: **Hot** = > 32%

Warm = 12-31%

Cool = < 11% (Based on frequency of visitor stops)

Stops at exhibition components (Percentage)- continued

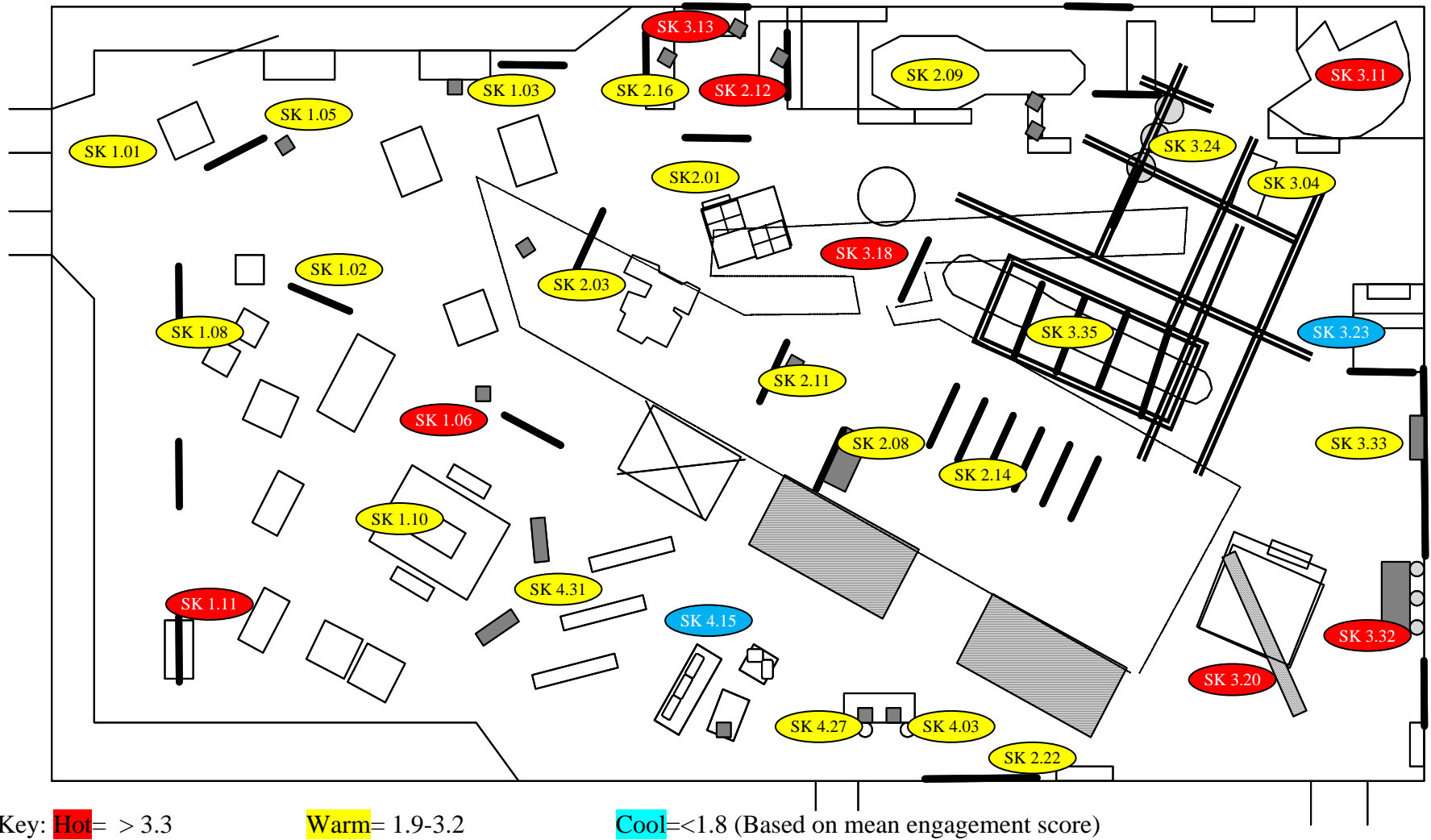


Key: **Hot** = > 32%

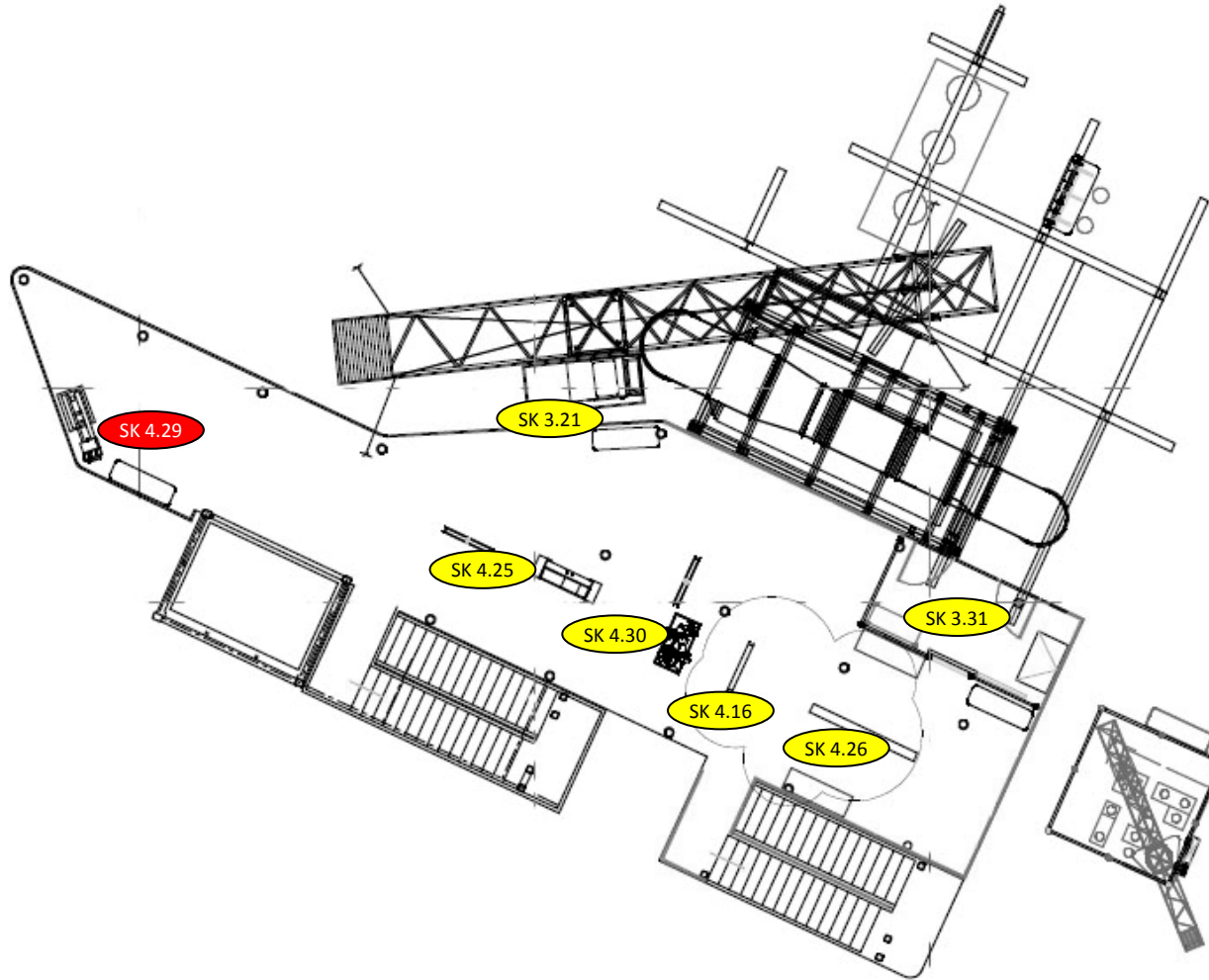
Warm = 12-31%

Cool = <11% (Based on frequency of visitor stops)

Figure 4: Heat Map for level of engagement with exhibition components



Level of engagement with exhibition components (Mean) - continued

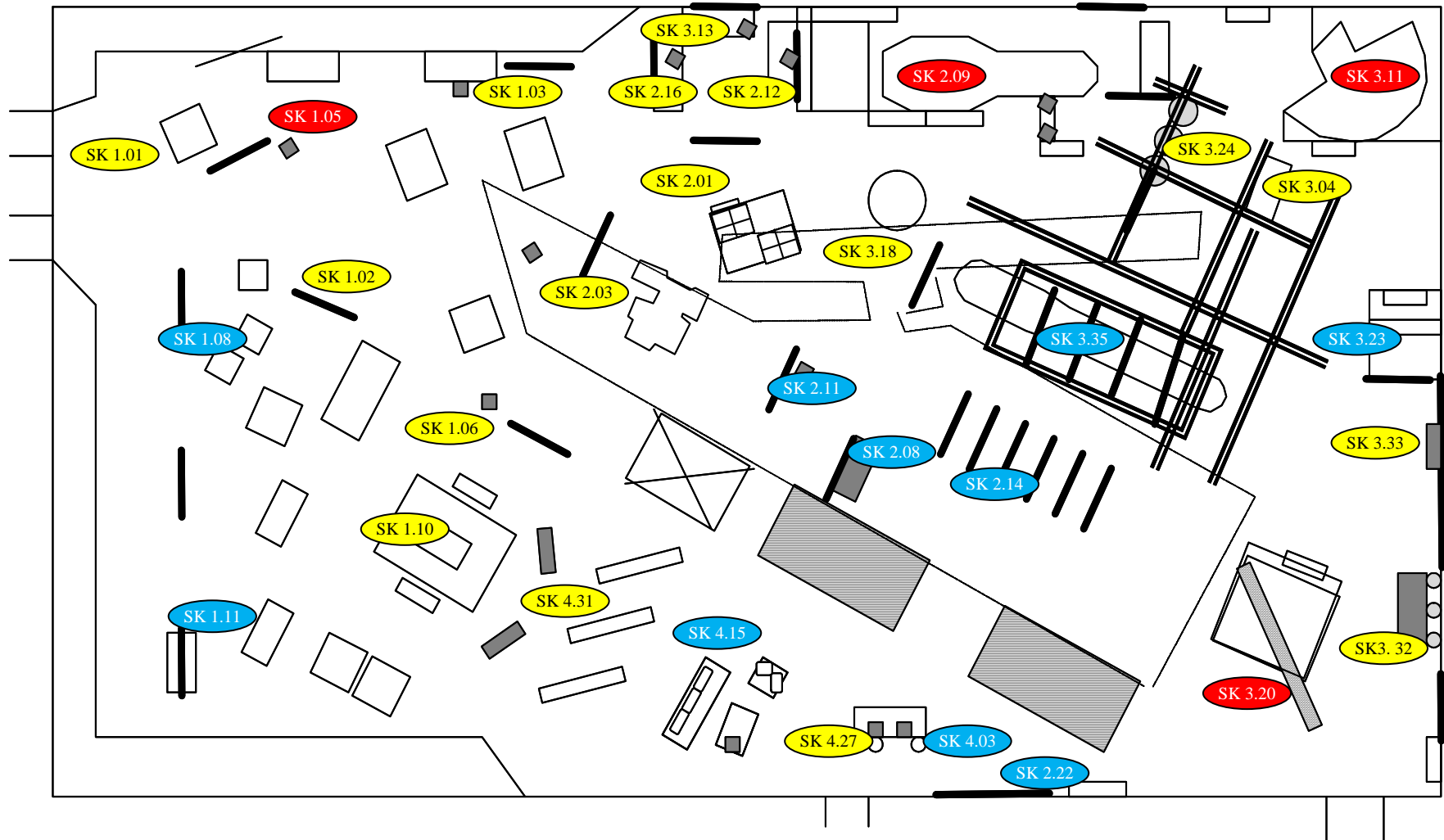


Key: **Hot** = > 3.3

Warm = 1.9-3.2

Cool = < 1.8 (Based on mean engagement score)

Figure 5: Heat Map for social interactions at exhibition components

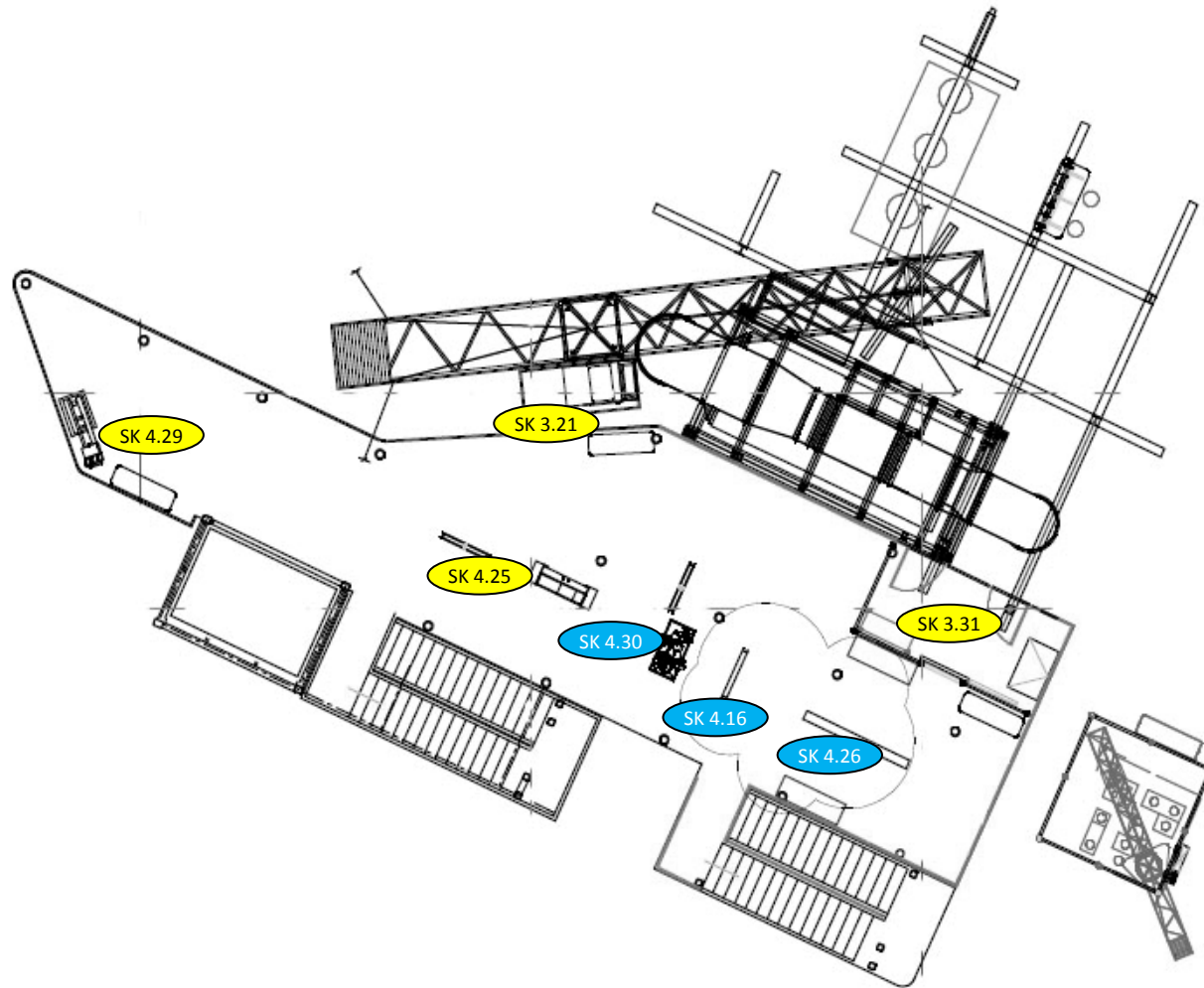


Key: **Hot** = > 15%

Warm = 5-14%

Cool = <4% (Based on frequency of visitor social interaction)

Social interaction at exhibition components (Percentage) - continued



Key: **Hot** = > 15%

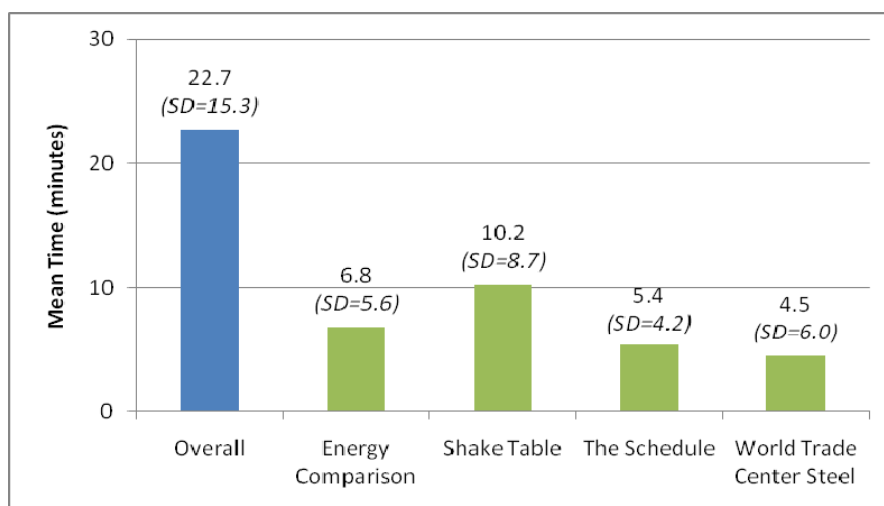
Warm = 5-14%

Cool = <4% (Based on frequency of visitor social interaction)

How did visitors use four key exhibits within Skyscraper! ?

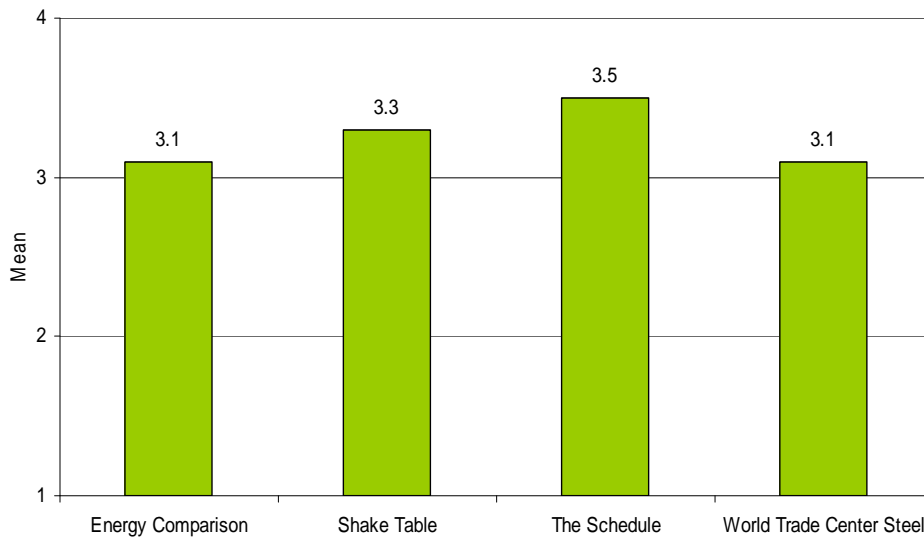
Structured observations with 95 visitors revealed relatively long stay times (or “holding power”) for the four key exhibition components (see Figure 6). The Shake Table was particularly successful in holding visitors’ attention: visitors spent on average 10 minutes with the exhibit. The other three key exhibits averaged 4.5 to 7 minutes of stay time. The extraordinary holding power of the Shake Table can at least partially be attributed to minimum time required to complete this hands-on activity. On the other hand, the World Trade Center Steel exhibit is less hands-on and interactive but visitors spent considerable time reading the text panel associated with the exhibit (see Table 22 in Appendix 4 for more details on timing and tracking data).

Figure 6: Time spent in the exhibition and in selected exhibits



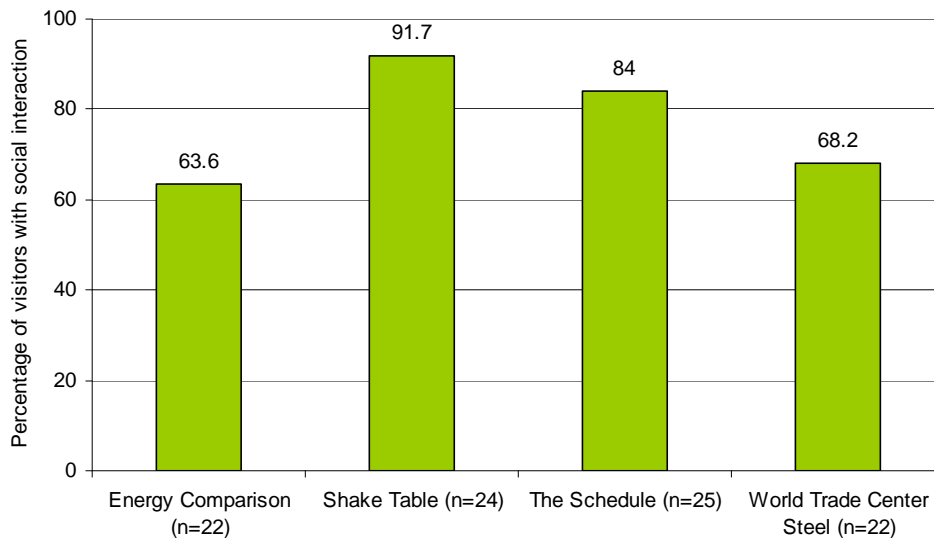
The relatively strong holding power of the four exhibits was accompanied by relatively high observed levels of engagement (see Figure 7): average engagement scores ranged from 3.1 to 3.5. For descriptive purposes, the average engagement levels with the Energy Consumption and World Trade Center Steel exhibits were considered moderate on the 4-point scale, whereas the far more interactive The Schedule and Shake Table had extensive interactions. No statistically significant differences were found when comparing the engagement level among these exhibits between groups of adults with groups with children.

Figure 7: Mean engagement level with four key exhibition components



During the structured observations, all four exhibits revealed relatively high incidences of social interactions. The Shake Table was the exhibit with the highest percentage of social interaction among visitors: 92% of the observed groups at the Shake Table were observed interacting with each other. The Shake Table was followed by The Schedule (84%), The World Trade Center Steel (68%), and Energy Comparison (64%) (see Figure 8). The high degree of interactivity at the Shake Table and The Schedule explains the high degree of social interaction at these exhibits.

Figure 8: Social interaction in selected exhibition components



⇒ Four key exhibits in *Skyscraper!* had strong holding power, engaged visitors on average moderately or extensively, and spurred relatively high levels of social interactions.

2. WHAT DID VISITORS TAKE AWAY FROM *SKYSCRAPER!*?

Description of the sample

Seventy-five visitors were interviewed upon exiting *Skyscraper!* A little over half of the interviewees were women (56%) and two-thirds were visiting the exhibition in a group that included at least one child (Table 9). Almost 60% of interviewees were between 25 and 45 years old. Half of the sample identified as white or Caucasian. Most respondents were either from New Jersey (69%) or from the greater metropolitan area (19%); about half of interviewees had visited the Liberty Science Center before, and of those, 19% had previously visited the *Skyscraper!* exhibition.

Table 9: Summary of sample characteristics by evaluation method

Characteristic	Exit Interview	Characteristic	Exit Interview
Sex	n=75	Race/ Ethnicity	n=75
Female	56%	Asian American or Pacific Islander	11%
Male	44%	Black or African American	13%
Group Type	n=75	Latino or Hispanic	15%
Adults Only	28%	Native American	0%
Alone	7%	White or Caucasian	52%
Family group	13%	Other or Mixed	9%
Group of friends	5%		
Organized group	3%	Prior visitation of Liberty Science Center	n=73
Adults with Children	67%	Yes	53%
Family group	60%	<i>Previously visited Skyscraper!</i>	n=37
Group of friends	7%	Yes	19%
Other	5%		
Age Category	n=75	Visiting from	n=73
18 - 24	12%	New Jersey	69%
25 - 34	24%	Greater Metropolitan Area	19%
35 - 44	35%	Out of State	10%
45 - 54	16%	Foreign Country	3%
55 - 64	7%		
65 - 74	5%		
75+	1%		

What do visitors think about skyscrapers?

Visitors were asked what comes to their minds when they think of skyscrapers. The most frequent image, shared by 73% of respondents was of a “tall building” (including iconic buildings, such as the World Trade Center and the Empire State Building). Another frequently mentioned idea was that of “large cities” (41%). About 9% of the respondents also associated skyscrapers with either some aesthetic or emotional images, or with processes involved in building a skyscraper (Table 10).

Table 10: What comes to mind when you think of skyscrapers?

	n	Percent (n=75)
Tall and large buildings; height	55	73
<i>World Trade Center</i>	(13)	(17)
<i>Empire State Building</i>	(9)	(12)
Large cities (e.g., mostly NYC, but also Chicago, Seattle, Hong Kong, Tokyo)	31	41
<i>Skyline of a city</i>	(6)	(8)
Construction of a buildings (e.g., engineering, safety, time, material, people)	7	9
Aesthetic and emotion	7	9
<i>Beauty, wonderment, good view</i>	(4)	(5)
<i>Fear, scary</i>	(3)	(4)
Other (King Kong, nose bleeds, window washers, glass facades)	5	7

⇒ Upon exiting the exhibition, few respondents connected the term “skyscraper” spontaneously with engineering, science, training/education or environmental aspects.

What big idea do visitors take away from visiting Skyscraper! ?

Respondents were asked what they thought were the exhibition’s Big Ideas, or main themes. The majority of visitors’ responses were directly related to the exhibition’s two main goals (see Table 11):

1. Designing, building and maintaining skyscrapers require knowledge of science, engineering, technology and mathematics and
2. Skyscrapers have a profound influence on our culture and on the natural world.

Responses were further matched with the exhibition’s seven major learning outcomes, and 88% of visitor responses touched on one of them:

- LO 1: Visitors will describe important processes and technologies used to design and build tall buildings.
- LO 2: Visitors will describe or map out major components of tall buildings (foundations, columns, capitals, load bearing beams, hanging walls, etc) and/or construction sequences.
- LO 3: Visitors will identify common building materials and give reasons as to why these materials are effective.
- LO 4: Visitors will list some systems and safety features that allow people to use and inhabit skyscrapers.
- LO5: Visitors will address environmental effects resulting from the concentration of large numbers of people.
- LO 6: Visitors will identify environmental issues that surround skyscrapers.
- LO 7: Visitors will talk about ways that skyscrapers affect quality of life in the city.

Table 11: What would you say was the Big Idea of this exhibition?

	n	Percent Respondents (n=69)
Related to Learning Outcomes		
Processes and technologies for building skyscrapers	48	70
Components of skyscrapers	6	8
Environmental effects and issues related to skyscrapers	4	6
Safety features of skyscrapers	3	4
Other responses		
Appreciation for skyscrapers	14	20
History of skyscrapers	6	8
Role of workers (architects, engineers, construction workers)	4	6

Note: Total equals more than 100% because visitors' responses could be coded into multiple categories

More than two-thirds of responses referred to processes and technologies for building skyscrapers, and were therefore related to Learning Outcome 1:

“It's a detailed look at how skyscrapers are built.”

“Dissecting skyscrapers. Explains how they work. The problems to solve in building them.”

“How skyscrapers are engineered and built to withstand different conditions.”

Respondents also mentioned, as the main idea of the exhibition, components of skyscrapers (8% of respondents) – related to Learning Outcome 2; environmental effects of skyscrapers (6% of respondents) – related to Learning Outcome 6; and safety features of skyscrapers (4% of respondents) – related to Learning Outcome 4:

“To teach kids about the structure of a skyscraper.” (Components)

“To get across the idea of how skyscrapers effect the environment.” (Environmental effects)

“[The] skyscraper exhibit allows you to think about safety and how correct design is meant to make them safe and tall.” (Safety)

Other responses included an appreciation of skyscrapers (20% of respondents); the history of skyscrapers (9% of respondents), and the roles of workers in building skyscrapers (6% of respondents):

“Interesting facts about tall buildings.” (Appreciation of skyscrapers)

“Open people's minds and show them amazing architecture.” (Appreciation of skyscrapers)

“What the evolution of skyscrapers has come from and where we are heading towards.”
(History)

“For common men to know what it takes to build a Skyscraper. The role of architecture and construction workers, the phases of construction.” (Role of workers)

“What a construction worker goes through.” (Role of workers)

- ⇒ Upon exiting the exhibition, the vast majority of respondents identified at least one Big Idea and one major learning outcome of *Skyscraper!* The most frequently mentioned perceived major theme of the exhibition was connected to the processes and technologies for building skyscrapers. [Note that respondents did not associate the term “skyscraper” with engineering, science, training/education or environmental aspects].
- ⇒ *Skyscraper!* was successful in creating awareness in visitors for the technological and organizational challenges in building skyscrapers.

Respondents were asked to identify which parts of the exhibition were most important in conveying the Big Idea (Table 12). Most visitors (84%, n=63) were able to identify at least one aspect of the exhibition that helped convey the Big Idea. Most of these responses indicated an exhibition component or exhibit (46%); the World Trade Center Steel (10%) and the I-Beam walk (9%) were the components most frequently mentioned.

About a quarter of respondents stated that the overall exhibition design conveyed the Big Idea. Most of these responses included a visual aspect of the design, such as videos, photos, graphics and text panels.

Another quarter of respondents felt that the Big Idea of the exhibition was carried by its content:

“Learning more about the history of skyscrapers.”

“All of the information on the boards.”

“Comparing and contrasting different skyscrapers around the world.”

A small number of respondents mentioned interactive and user-friendly aspects of the exhibition and identified all exhibits as carrying the Big Idea:

“Walking the I-beam and building your own building.” (Usability and interactivity)

Table 12: Elements of the exhibition identified by respondents as most important in conveying the Big Idea

	n	Percent (n=70)
Components	32	46
WTC and beam	(7)	(10)
I-Beam Walk the I-Beam	(6)	(9)
Crane Simulator	(5)	(7)
NY Schedule	(5)	(7)
Wind Tunnel	(5)	(7)
Foundation Testing	(4)	(6)
Curtain Wall	(3)	(4)
Elevator	(2)	(3)
Shake Table	(3)	(4)
Excavator	(1)	(1)
Design	18	26
Content	17	24
Interactivity and usability	3	4
All of the exhibit	3	4
Personal connection	1	1
None of the exhibit or do not know	7	10

⇒ Respondents identified a variety of exhibition features and components that were mostly responsible for carrying the Big Idea, an indication that the exhibition provided visitors with a variety of different ways to personally connect with the perceived major theme(s) of Skyscraper. Three of the four key exhibits were mentioned by respondents as contributing to their understanding of the Big Idea.

Do visitors leave the exhibition with an understanding of what training is needed to build skyscrapers?

Visitors were asked about the type of training required to build a skyscraper, and subsequently asked to indicate whether that understanding preceded their visit to the *Skyscraper!* exhibition. The vast majority of respondents (91%, n=68) indicated at least one aspect of training that is needed to design or build a skyscraper (see Table 13). More than half of the responses mentioned architecture (55%) or engineering (51%). Other types of training mentioned included construction (19%), science-related training (12%), design (8%), and urban planning (3%). Some respondents did not indicate a specific training, but that “a lot of training” was needed (15%).

Respondents were also asked if their answers were based on previous knowledge, were reinforced by the exhibition or gained anew (Table 13). Most respondents indicated that they already knew about the training required to design and build skyscraper, although more than a third also felt that the exhibition reminded them of their pre-existing knowledge (41% “already knew” and 35% were reminded). The remaining quarter of respondents, who “discovered today” the training needed to build skyscrapers, were less likely to indicate “architecture” than those who had previous knowledge, and more likely to focus on “construction” or the fact that “a lot of training” was needed.

Table 13: Respondents' understanding of training required to design and build skyscrapers

	Already knew (n=28)	Exhibit helped remember (n=24)	Discovered today (n=16)	Total n	Total (n=75)
Architecture	68%	71%	31%	41	55%
Engineering	64	54	44	38	51
Construction	14	21	31	14	19
A lot of training, whole team	7	17	31	11	15
Science - Physics, Math	14	17	6	9	12
Design	4	17	6	6	8
Urban planning	4	4	0	2	3
Do not know	-	-	-	7	9
Total	41	35	24		

⇒ The exhibition may have created new awareness about the professional field involved in designing and building skyscrapers in about a quarter of respondents; another third of respondents were reminded of existing knowledge. The majority of respondents felt that they had already been aware of the skills and knowledge required in the construction of skyscrapers.

Do visitors understand the issues that face engineers in building skyscrapers?

The vast majority of respondents (95%, n=72) indicated issues that engineers face when building a skyscraper (Table 14). Issues related to environmental conditions were the most frequently mentioned (43%). Other frequently mentioned issues related to processes and technologies (40%), such as structure and design, or related to skyscraper components (40%), such as foundation and materials. Issues related to skyscraper location and urban planning were mentioned by 32% of respondents. Safety features of skyscrapers were indicated by 19% of respondents.

The majority of respondents indicated that they had previous knowledge of the subject (44% “already knew” and 35% were reminded). About one-fifth of respondents discovered during their visit to the exhibition the issues that engineers face when building skyscrapers. These respondents were more likely than others to indicate components of skyscrapers, such as foundation and materials. Those who had been reminded of these issues were more likely than others to indicate environmental effects and processes and technologies associated with building skyscrapers. Those who felt that they had already been aware of these issues were more likely than others to mention the location of skyscrapers and issues of urban planning.

Table 14: Respondents' understanding of issues engineers must consider when building skyscrapers

	Already knew (n=31)	Exhibit helped remember (n=25)	Discovered today (n=15)	Total n	Total (n=73)
Environmental effects and issues related to skyscrapers	36	52	40	31	43
Processes and technologies for building skyscrapers	23	60	40	29	40
Building structure and architecture of skyscrapers	(23)	(48)	(33)	(25)	(34)
Design	(0)	(12)	(7)	(4)	(6)
Components of skyscrapers	26	34	67	29	40
Foundation	(19)	(28)	(53)	(21)	(29)
Building materials of skyscrapers	(7)	(16)	(13)	(8)	(11)
Location and urban planning	45	24	20	23	32
Safety features of skyscrapers	23	16	20	14	19
Do not know	-	-	-	1	1
Total	44	35	21		

⇒ The exhibition may have created new awareness about issues faced by engineers when building skyscrapers in about one-fifth of respondents; another third were reminded of existing knowledge. The majority of respondents felt that they had already been aware of the issues faced by engineers when building skyscrapers.

What effects do skyscrapers have on the environment?

Three-quarter of respondents were able to indicate positive or negative ways in which skyscrapers affect the environment (Table 15). Negative effects were most frequently mentioned and included the use of resources and energy (22%); changes in natural cycles caused by skyscrapers (19%); negative effects on urban planning (17%); and general pollution (15%). About a quarter of respondents mentioned positive environmental effects of skyscrapers, such as the development of green technologies, attraction of jobs and tourism, and efficient use of space.

The majority of respondents indicated having previous knowledge of the issues (48% “already knew” and 30% were reminded). Those who learned that day about the environmental effects of skyscrapers were less likely than the others to indicate negative effects like the use of resource and energy and changes in natural cycles, and more likely to indicate potential positive effects of skyscrapers.

⇒ The exhibition may have created awareness about positive and negative environmental issues associated with skyscrapers. About one-fifth of respondents encountered these issues for the first time, and about one-third were reminded of them by the exhibition.

Table 15: Respondents' understanding of how skyscrapers affect the environment

	Already knew (n=27)	Exhibit helped remember (n=17)	Discovered today (n=12)	n	Total (n=69)
Negative					
Use of resources and energy	22%	41%	17%	15	22%
Changes in natural cycles (heat, wind, habitat loss)	15	41	17	13	19
Location and urban planning (block views, take up space)	19	18	25	12	17
Pollution	26	6	17	10	15
Positive					
Green technologies and other positive effects, such as jobs, tourist attraction, and efficient use of space	30	29	42	18	26
Do not know	-	-	-	12	17
Total	48	30	21		

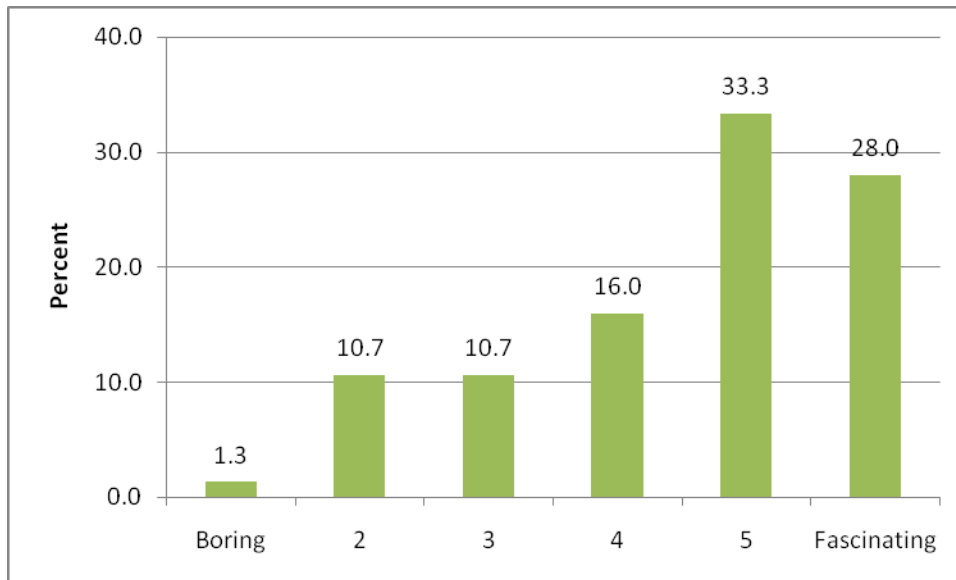
3. WHAT WAS THE APPEAL OF THE EXHIBITION AND OF SPECIFIC EXHIBITS AND HOW SATISFIED WERE VISITORS WITH THEIR EXPERIENCE?

Visitors' reactions to the exhibition, as well as their satisfaction, were assessed using Specific Component Observation and Interviews and Exit Interviews.

Visitor satisfaction with the exhibition

Exit interview respondents rated the exhibition positively. Almost two-thirds of respondents (61%) rated the exhibition as 5 or 6 on a 6-point, semantic differential scale with “boring” and “fascinating” as anchor points (Figure 9). The average score was 4.7 (with a standard deviation of 1.4). Nearly 23% of respondents rated the exhibition low, with a score of 1, 2 or 3.

Figure 9: Visitors' Satisfaction with Exhibition (n=75)



⇒ *Skyscraper!* was rated positively by about 60% of respondents, and rated negatively by about 23%. The mean rating of 4.7 compares with similar ratings for science exhibitions in other venues for which a 6-point satisfaction item was used.

Most and least appealing aspects of the exhibition

Visitors were also asked what they enjoyed and did not enjoy about the exhibition. Their responses were categorized into the following:

1. Design: included aspects of the exhibition related to text, audio and visuals.
2. Component: included the citation of specific exhibits, without much explanation as to why visitors enjoyed or did not enjoy them.
3. Usability and interactivity: referred to responses related to the ability to use the exhibit, including qualities such as interactivity and hands-on.
4. Overall reaction: included general positive or negative comments about the exhibition, without many details as to why.
5. Content: included comments about the topic of the exhibition, including the ability to learn new information.
6. Personal connection: included comments about previous experiences that related to the exhibition.
7. Visitor flow: related to crowdedness of the space.
8. Audience appropriateness: related to accessibility of the exhibits to either adults or children.

The majority of respondents (60%) enjoyed a specific exhibit component, with the I-Beam Walk the most frequently mentioned component (“*[I] had a blast walking the I-Beam*”) (see Table 16). An equal number of respondents (n=23; 31%) expressed an overall positive reaction (“*It*

was fun”), or referenced the general content of the exhibition (“*Very informative; explains to layman the mechanics; “interesting, new things to learn about skyscrapers”*”).

Table 16: What participants enjoyed and did not enjoy about the exhibition (n=75)

	Enjoyed		Did not enjoy	
	n	%	n	%
Component	45	60	10	13
Overall reaction	23	31	4	5
Content	23	31	13	17
Audience appropriateness	15	20	8	11
Usability and interactivity	14	19	34	45
Personal connection	8	11	0	0
Design	5	7	16	21
Visitor flow	0	0	3	4

One-fifth of respondents enjoyed that the exhibition was appropriate for the audience (“*Gets kids interested in skyscraper design*”) and that it provided a high degree of usability and interactivity (“*Putting together beam construction - they like to build stuff and try them out*”).

The ability to make personal connections (“*WTC Beam because of our location in comparison to the 9/11 attacks*”) and the overall exhibition design (“*[I] have never seen such amazing pictures. [I] am amazed how LSC put it all together*”) were the categories less frequently mentioned as what respondents enjoyed about the exhibition:

Almost half of the respondents (45%) indicated dissatisfaction with the lack of interactivity or problems with using the exhibit:

“There are things not working. The models look good, but there is nothing to do (only look and read).”

“[The] wooden blocks were out of reach for the excavator.”

“Missing pieces on the Shake Table.”

Respondents were also critical of the general design of the exhibition (21%), its content (17%), and some of the exhibition components or exhibits (13%):

“Not all is interactive, not enough interaction. [paraphrased: My kids didn't like the pictures or videos].”

“[I] didn't enjoy it: too many things to read.”

“Too many panels and reading stuff. [We] liked looking at them [the panels] but didn't read them.”

“It was pointless, had nothing to do with science.”

“Some technical stuff was too technical - e.g. Wind Tunnel.”

The categories less frequently mentioned were “audience appropriateness” (11%), “reactions” (5%), and visitor flow (4%).

“The children were too young to really understand it.”

“Some exhibits are hard to understand for the lay person.”

“It was very crowded.”

⇒ Respondents most enjoyed specific exhibition components and exhibits and the overall content of the exhibition. However, many respondents least enjoyed a lack of hands-on or interactive experiences and problems with the use or usability of specific exhibits or exhibit elements.

Most and least appealing aspects of four key exhibits

Visitor reaction was also assessed for the key exhibits Shake Table, The Schedule, World Trade Center Steel and Energy Comparison, using the focused component observation and interview protocol. Responses were coded into eight categories: design, component, usability and interactivity, overall reaction, content, personal connection, visitor flow, and audience appropriateness.

Initially, visitors were asked what they enjoyed about or what attracted them to the specific exhibits at which they were interviewed (Table 17). Overall, 93% of respondents indicated some aspect of the exhibits that were enjoyable or attractive to them. Energy Comparison, The Schedule and the World Trade Center Steel exhibits received fairly high overall positive reactions.

Table 17: What visitors most enjoyed or were attracted to by exhibits

	Energy Comparison (n=19)	Shake Table (n=22)	The Schedule (n=23)	World Trade Center Steel (n=24)	Total n	(n=88)
Design	26%	14%	52%	63%	35	40%
Component	11	5	48	8	16	18
Usability and interactivity	79	68	35	0	38	43
Overall reaction to the exhibit	84	50	70	88	64	73
Exhibit content	5	18	35	17	17	19
Personal connection	21	23	17	83	33	38
Visitor flow	16	36	22	4	17	19
Audience appropriateness	-	-	-	-	-	-

Respondents at Energy Comparison and Shake Table most enjoyed or were attracted to the interactive nature of the exhibits, while the World Trade Center Steel exhibit was enjoyed or attracted respondents for its ability to allow visitors to make personal connections and for its overall design. The Schedule did not have a single dominant feature that was mentioned by respondents as particularly enjoyable or attractive. Instead, about half of respondents who were interviewed at that exhibit mentioned as enjoyable or attractive the overall design and exhibit components of the Schedule.

Respondents at the key exhibits were also asked what they did not enjoy about the exhibits (Table 18). Overall, only 40% of respondents indicated aspects of the exhibits that they did not enjoy. Most responses referred to the design (34%) and the usability and interactivity of exhibits (34%), and many of these referred to The Shake Table’s usability and interactivity (and related audience appropriateness) and The Schedule’s overall design.

“[The] sound is too low; [I] couldn't hear anything.” (The Schedule)

“Hard to read the titles and subtitles, [the] font was too small.” (The Schedule)

“Hard to understand how to make it work; [the] exhibit [is] not working, didn't shake.”
(Shake Table)

“[It is] not easy to use; not clear what to do, the building fell too easily and too quickly.”
(Shake Table)

“It was too hard; it felt like there was no solution.” (Shake Table)

“Thought it would allow for different results, but it always falls.” (Shake Table)

“We didn't know where a particular piece goes when building the building. The instructions don't say how to build the building.” (Shake Table)

Table 18: What visitors least enjoyed about selected components

	Energy Comparison (n=9)	Shake Table (n=17)	The Schedule (n=9)	World Trade Center Steel (n=3)	Total n	Total (n=38)
Design	4	2	6	1	13	34%
Component	0	0	2	0	2	5
Usability and interactivity	1	11	1	0	13	34
Overall reaction to the exhibit	3	2	0	1	6	16
Exhibit content	2	1	1	0	4	11
Personal connection	-	-	-	-	-	-
Visitor flow	0	0	0	1	1	3
Audience appropriateness	3	4	1	0	8	21

- ⇒ Respondents most enjoyed the hands-on nature of Energy Comparison and the Shake Table, and they enjoyed the opportunity and ability to make personal connections with the World Trade Center Steel exhibit.
- ⇒ Respondents also pointed to some problems with using the Shake Table and critiqued some design aspects of The Schedule.

CONCLUSIONS AND RECOMMENDATIONS

The results of the summative evaluation suggest that *Skyscraper!* was successful on a variety of measures. Visitor critique centered on a perceived lack of hands-on or interactive experiences.

1. Timing and tracking data and structured observation suggest that visitors to *Skyscraper!* were exposed to a variety of experiences that can lead to enjoyment and learning.

Timing and tracking data suggest that visitors spent considerably more time in *Skyscraper!* than in exhibitions with similar number of exhibits in other science centers. However, visitors spent less time than expected in *Skyscraper!* when measured by the floor space (a less concise standard than number of exhibition elements). Visitors attended to, on average, slightly fewer than 20% of the available exhibits and exhibition elements, but showed relatively strong average engagement for those exhibits with which they engaged.

There was a strong overlap between popular and engaging exhibits in *Skyscraper!* Behavioral data suggest that visitors were exposed to some of the key exhibits and interacted considerably with some others, providing visitors with the exposure needed to gain some understanding from their visit to *Skyscraper!* Four key exhibits in *Skyscraper!* had strong holding power, engaged visitors on average moderately or extensively, and revealed relatively frequent occurrences of social interactions.

2. Exit interviews with visitors to the exhibition and users of four key exhibits suggest that about one-fifth to a quarter of visitors may have learned new material, mostly at the level of awareness and basic knowledge, and that about one-third of visitors were able to access and reinforce latent awareness and knowledge.

Skyscraper! was successful in creating awareness in visitors for the technological and organizational challenges in building skyscrapers. Upon exiting the exhibition, the vast majority of respondents identified at least one Big Idea and one major learning outcome of *Skyscraper!* The most frequently mentioned perceived major theme of the exhibition was connected to the processes and technologies for building skyscrapers, despite the fact that few respondents mentioned engineering, science, training/education or environmental aspects when asked to free-associate the term “skyscraper.”

Respondents identified a variety of exhibition features and components as mostly responsible for carrying the Big Idea, an indication that the exhibition provided visitors with a variety of different ways to personally connect with the perceived major theme(s) of *Skyscraper!* Three of the four key exhibits were mentioned by respondents as contributing to their understanding of the Big Idea.

The exhibition may have created new awareness about the professional field involved in designing and building skyscrapers in about a quarter of respondents; another third of respondents were reminded of pre-existing knowledge. The majority of respondents felt

that they had already been aware of the skills and knowledge required in the construction of skyscrapers. The exhibition may have created new awareness about issues faced by engineers when building skyscrapers in about one-fifth of respondents; another third of respondents were reminded of existing knowledge. Most respondents felt that they were already aware of the issues faced by engineers when building skyscrapers. Finally, the exhibition may have created awareness about positive and negative environmental issues associated with skyscrapers. About one-fifth of respondents encountered these issues for the first time, and about one-third were reminded of them by the exhibition.

3. *Skyscraper!* was perceived positively by visitors.

Skyscraper! was rated positively by about 60% of respondents, and rated negatively by about 23%. The mean rating of 4.7 compares with similar ratings for other exhibitions for which a 6-point satisfaction item was used.

4. Visitors would have liked more interactive and hands-on experiences in *Skyscraper!*

Respondents most enjoyed specific exhibition components and exhibits and the overall content of the exhibition. However, many respondents least enjoyed a lack of hands-on or interactive experiences and problems with the use or usability of specific exhibits or exhibit elements.

Respondents most enjoyed the hands-on nature of Energy Comparison and the Shake Table, and they enjoyed the opportunity and ability to make personal connections with the World Trade Center Steel exhibit. Respondents also pointed to some problems with using the Shake Table and critiqued some design aspects of The Schedule.

5. A few design changes have the potential to increase visitor satisfaction and learning.

The exhibition currently lacks an advance organizer, orientation guide, or map of *Skyscraper!* Providing a map or advance organizer at the entrance and at key locations within the exhibition space can help visitors connect to the Big Ideas and main themes, and help them understand where key content messages can be found.

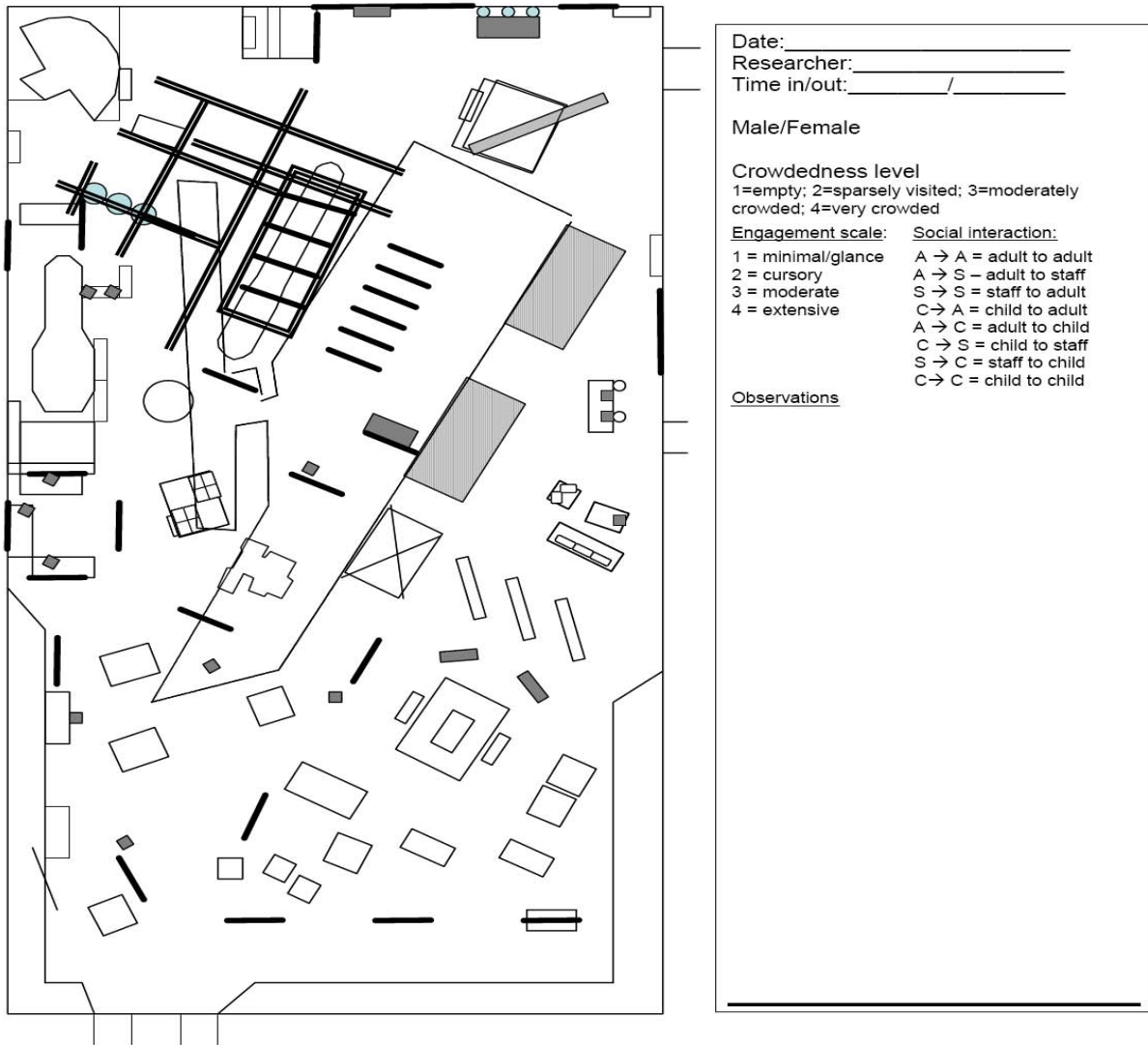
Timing and tracking data revealed an area at the base of the staircases leading to the second floor that did not draw visitors' attention. Providing more attractive signage or adding other interactive exhibits along that side of the exhibition may increase visitation to that area. Tracking data also showed that only about fifty percent of visitors actually visited the second floor of the exhibition. More detailed signage for the second floor near the staircases may increase visitation.

Several exhibits required staff facilitation and therefore were only available to visitors on a limited basis. It would be helpful to post the times of the facilitated activities at the entrance of the exhibition and at the exhibits themselves. Video consoles that show the interactive in use when no facilitation is available may provide value to visitors.

APPENDICES

APPENDIX 1: TRACKING TOOL

Figure 10: Tracking Tool



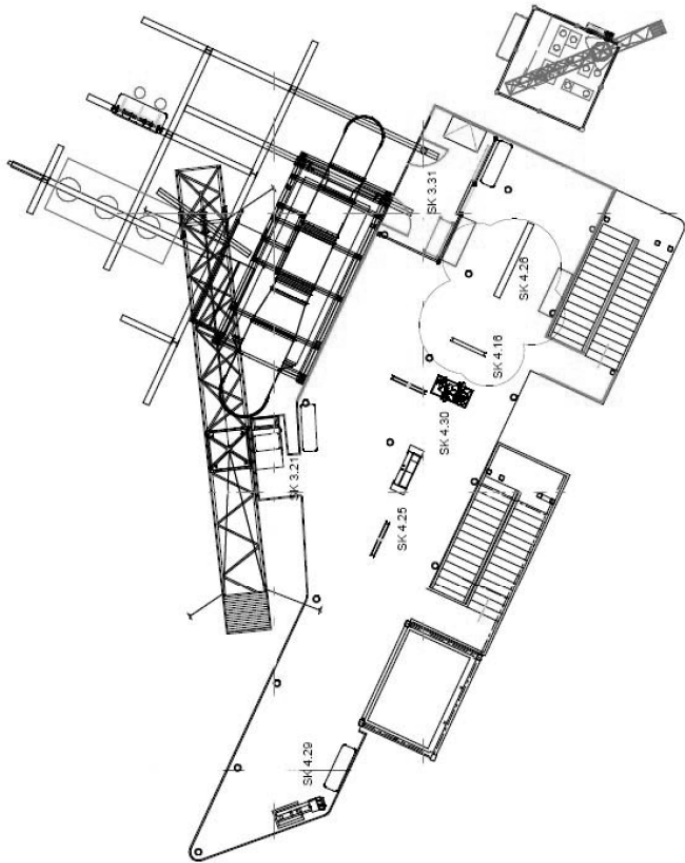
Date: _____
Researcher: _____
Time in/out: _____ / _____

Male/Female

Crowdedness level
1=empty; 2=sparsely visited; 3=moderately crowded; 4=very crowded

Engagement scale: Social interaction:
1 = minimal/glance A → A = adult to adult
2 = cursory A → S = adult to staff
3 = moderate S → S = staff to adult
4 = extensive C → A = child to adult
 A → C = adult to child
 C → S = child to staff
 S → C = staff to child
 C → C = child to child

Observations



Date: _____
 Researcher: _____
 Time in/out: _____ / _____

Male/Female

Crowdedness level
 1=empty; 2=sparsely visited; 3=moderately crowded; 4=very crowded

Engagement scale:
 1 = minimal/glance
 2 = cursory
 3 = moderate
 4 = extensive

Social interaction:
 A → A = adult to adult
 A → S = adult to staff
 S → S = staff to adult
 C → A = child to adult
 A → C = adult to child
 C → S = child to staff
 S → C = staff to child
 C → C = child to child

Observations

APPENDIX 2: EXIT INTERVIEW

Hi! My name is _____ and I am working with Liberty Science Center. We are interested in talking to people about their thoughts about the *Skyscraper!* Exhibition. Your input is very important. The interview will only take about 5 to 10 minutes. At the end, we'll provide you with a small token of our appreciation. Would you mind talking with me briefly?

1. On a scale of 1 to 6, how would you rate *Skyscraper!*? Where 1 is boring and 6 is fascinating.

1 2 3 4 5 6

2. Why did you choose this rating?

3. When you think about skyscrapers what comes to mind?

4. What in *Skyscraper!* did you find most fascinating, interesting or enjoyable? Probe for Why?

5. What was least fascinating, interesting or enjoyable? Probe for Why?

6. What would you say was the Big Idea of this exhibition? [How would you describe the exhibition to a friend?]

7. Which parts of this exhibit were most important in conveying the Big Idea?

Now I am going to hand you a three point scale where 1 is "I already knew this", 2 is "the exhibit helped me remember this" and three is "I discovered this today", after each question I will ask you rate your response using this scale.

8. What kind of training do you think someone needs to build and design a skyscraper?

Based on your response how would you rate this using the three point scale?_____

9. What are some issues engineers must consider when building a skyscraper?

Based on your response how would you rate this using the three point scale?_____

10. In what ways do skyscrapers affect the environment?

Based on your response how would you rate this using the three point scale?_____

Would you mind taking a minute and filling out this form for us? Thank you!

If using token of appreciation hand them out when they return the demographic form.

Please tell us about yourself...

1. Who did you come to the museum with today?

- Alone
 Family group (all adults)
 Group of friends (all adults)
 Other: _____
- Family group (with children)
 Group of friends (with children)
 Organized group (i.e., church, school)

2. Have you been to the Liberty Science Center before today?

- Yes
If YES, Had you seen the *Skyscraper!* exhibition before? Yes No

3. What is your age?

- 18-24 years
 45-54 years
 55-64 years
- 25-34 years
 65-74 years
- 35-44 years
 74+ years

4. Where are you from?

- NJ town: _____ Greater Metropolitan Area Out of State
- Foreign Country

5. Would you describe yourself as?

- Asian American or Pacific Islander
 Black or African American
 Latino or Hispanic
 Native American
 White or Caucasian
 Other or mixed

6. What is your gender?

- Male Female

Thank you so much for your help.

APPENDIX 3: SPECIFIC COMPONENT OBSERVATION AND INTERVIEWS

Structured observation/interview

3.33 The Schedule .

Start Time: _____

End Time: _____

Where/what do they start with?

Degree of engagement (1-4)

Social interaction (yes/no)

Notes:

Approach

Excuse me, I am with the Museum, and I noticed you were using the timeline a moment ago. We're trying to find out what visitors think about this exhibit, and I'm wondering if I could get your opinion on a few things? (Thank you.)

Questions:

1. What attracted you to this exhibit? What did you look at?
2. What interested you in these things?
3. Did you like what you saw or read? What did you like about it?
4. Was there anything you saw or read that you disliked? Why?

Thank you! Your feedback really helps us improve the museum.

-----OBSERVED DATA-----

Sex (*Circle one*): Male Female

Group (*Circle one*): Adult only Adult with kids

Age (*Circle one*): 18-20s 30s 40s 50s 60s+

Structured observation/interview
2.12 Shake Table

Start Time: _____

End Time: _____

Where/what do they start with?

Degree of engagement (1-4)

Social interaction (yes/no)

Notes:

Approach

Excuse me, I am with the Museum, and I noticed you were using the timeline a moment ago. We're trying to find out what visitors think about this exhibit, and I'm wondering if I could get your opinion on a few things? (Thank you.)

Questions:

1. What attracted you to this exhibit? What did you look at?
2. What interested you in these things?
3. Did you like what you saw or read? What did you like about it?
4. Was there anything you saw or read that you disliked? Why?

Thank you! Your feedback really helps us improve the museum.

-----OBSERVED DATA-----

Sex (*Circle one*): Male Female

Group (*Circle one*): Adult only Adult with kids

Age (*Circle one*): 18-20s 30s 40s 50s 60s+

Structured observation/interview
4.27 Energy Comparison

Start Time: _____

End Time: _____

Where/what do they start with?

Degree of engagement (1-4)

Social interaction (yes/no)

Notes:

Approach

Excuse me, I am with the Museum, and I noticed you were using the timeline a moment ago. We're trying to find out what visitors think about this exhibit, and I'm wondering if I could get your opinion on a few things? (Thank you.)

Questions:

1. What attracted you to this exhibit? What did you look at?
2. What interested you in these things?
3. Did you like what you saw or read? What did you like about it?
4. Was there anything you saw or read that you disliked? Why?

Thank you! Your feedback really helps us improve the museum.

-----OBSERVED DATA-----

Sex (*Circle one*): Male Female

Group (*Circle one*): Adult only Adult with kids

Age (*Circle one*): 18-20s 30s 40s 50s 60s+

Structured observation/interview
SK.ex.3.18 World Trade Center Steel

Start Time: _____

End Time: _____

Where/what do they start with?

Degree of engagement (1-4)

Social interaction (yes/no)

Notes:

Approach

Excuse me, I am with the Museum, and I noticed you were using the timeline a moment ago. We're trying to find out what visitors think about this exhibit, and I'm wondering if I could get your opinion on a few things? (Thank you.)

Questions:

1. What attracted you to this exhibit? What did you look at?
2. What interested you in these things?
3. Did you like what you saw or read? What did you like about it?
4. Was there anything you saw or read that you disliked? Why?

Thank you! Your feedback really helps us improve the museum.

-----OBSERVED DATA-----

Sex (*Circle one*): Male Female

Group (*Circle one*): Adult only Adult with kids

Age (*Circle one*): 18-20s 30s 40s 50s 60s+

APPENDIX 4: ADDITIONAL RESULTS

Table 19: Summary of time spent in selected exhibits (in minutes)

Area	n	Median	Mode	Mean	Standard Deviation	Min	Max
Energy Comparison	22	5	2	6.8	5.6	2	25
Sex							
Female	16	5.5	2	7.6	6.4	2	25
Male	5	5	3	4.8	2.0	3	8
Group Type							
Adults Only	10	4	2 ^a	4.9	3.5	2	13
Adults with Children	11	8	2 ^a	8.7	6.9	2	25
Shake Table	23	7	3	10.2	8.7	0	33
Sex							
Female	12	6	3 ^a	8.5	7.1	0	22
Male	11	9	4	12.0	10.2	2	33
Group Type							
Adults Only	2	5	3	5.0	2.8	3	7
Adults with Children	21	9	5	10.7	9.0	0	33
The Schedule	25	4	3	5.4	4.2	1	20
Sex							
Female	12	4	5	4.0	2.4	1	10
Male	12	5	3	7.0	5.3	3	20
Group Type							
Adults Only	8	5.5	3	6.4	4.1	2	14
Adults with Children	16	4	5	5.1	4.5	1	20
World Trade Center Steel	24	3	1	4.5	6.0	0	29
Sex							
Female	10	2	1	5.6	8.7	1	29
Male	13	3	1 ^a	3.8	3.2	0	10
Group Type							
Adults Only	11	3	1	6.3	8.2	1	29
Adults with Children	13	3	1	3.1	2.7	0	10

^a Multiple modes exist. The smallest value is shown

- The non-parametric test Kruskal-Wallis was used to detect differences in time spent among the exhibits. Visitors spent significantly less time in the World Trade Center Steel than in the Shake Table and Energy Comparison ($\chi^2_{k-w}=10.73$, $df=3$, $p<0.05$). No other differences were found.
- The non-parametric test Mann-Whitney U was used to detect differences in time spent between males and females, and adults only and adults with children, in each exhibit. . No statistically significant differences were found.

Table 20: Level of engagement with selected exhibition components

Area	n	Median	Mode	Mean	Standard Deviation	Min	Max
Energy Comparison	22	3	4	3.1	0.95	1	4
Sex							
Female	16	3	4	2.9	1.0	1	4
Male	5	4	4	3.6	0.5	3	4
Group Type							
Adults Only	10	3.5	4	3.1	1.1	1	4
Adults with Children	11	3	3 ^a	3.1	0.8	2	4
Shake Table	23	3	4	3.3	0.86	1	4
Sex							
Female	13	3	3	3.2	0.9	1	4
Male	10	4	4	3.4	0.8	2	4
Group Type							
Adults Only	2	3	3	3.0	0.0	3	3
Adults with Children	21	4	4	3.3	0.9	1	4
The Schedule	24	4	4	3.5	0.78	2	4
Sex							
Female	11	4	4	3.5	0.8	2	4
Male	12	4	4	3.4	0.8	2	4
Group Type							
Adults Only	7	4	4	3.6	0.8	2	4
Adults with Children	16	4	4	3.4	0.8	2	4
World Trade Center Steel	21	3	3	3.1	0.81	2	4
Sex							
Female	9	3	2 ^a	3.0	0.9	2	4
Male	11	3	3	3.0	0.8	2	4
Group Type							
Adults Only	9	3	3	3.1	0.8	2	4
Adults with Children	12	3	2 ^a	3.0	0.9	2	4

^a Multiple modes exist. The smallest value is shown

- The non-parametric test Kruskal-Wallis was used to detect differences in engagement level among the exhibits. No statistically significant differences were found.
- The non-parametric test Mann-Whitney U was used to detect differences in engagement level between males and females, and adults only and adults with children, in each exhibit. . No statistically significant differences were found.

Table 21: Social interaction in selected exhibition components

Area	N	n	Percent
Energy Comparison	22	14	63.6
Sex			
Female	16	10	62.5
Male	5	4	80.0
Group Type			
Adults Only	10	6	60.0
Adults with Children	11	8	72.7
Shake Table	24	22	91.7
Sex			
Female	13	12	92.3
Male	11	10	90.9
Group Type			
Adults Only	2	1	50.0
Adults with Children	22	21	95.5
The Schedule	25	21	84.0
Sex			
Female	12	9	75.0
Male	12	11	91.7
Group Type			
Adults Only	8	6	75.0
Adults with Children	16	14	87.5
World Trade Center Steel	22	15	68.2
Sex			
Female	9	7	77.8
Male	12	7	58.3
Group Type			
Adults Only	9	4	44.4
Adults with Children	13	11	84.6

- The non-parametric test Chi-square was used to detect differences in social interaction among the exhibits. No statistically significant differences were found.

Small sample did not allow for tests to compare males and females and adult only and adults with children, within exhibits.

Table 22: Summary of timing and tracking data

	Frequency of Stops		Engagement Score (1-4) mean	Stops/ Engag. Scores	Social Interaction		Stops/ Social Interaction
	n	%			n	%	
SK1.01	15	28.0	2.7	2warm	7	12.0	2warm
SK1.02	6	12.0	3.0	2warm	3	6.0	2warm
SK1.03	11	22.0	2.5	2warm	3	6.0	2warm
SK1.05	18	36.0	2.8	1hot	10	20.0	1hot
SK1.06	15	30.0	3.3	1hot	6	12.0	2warm
SK1.08	3	6.0	2.3	3cold	1	2.0	3cold
SK1.10	14	28.0	3.1	2warm	3	6.0	2warm
SK1.11	3	6.0	3.3	2warm	0	0.0	3cold
SK2.01	21	42.0	2.7	1hot	7	14.0	1hot
SK2.03	14	28.0	2.5	2warm	5	10.0	2warm
SK2.08	1	2.0	3.0	3cold	0	0.0	3cold
SK2.09	15	30.0	3.0	2warm	8	16.0	1hot
SK2.11	8	16.0	2.8	2warm	2	4.0	3cold
SK2.12	10	20.0	3.4	1hot	6	12.0	2warm
SK2.14	4	8.0	2.3	3cold	1	2.0	3cold
SK2.16	6	12.0	2.8	2warm	3	6.0	2warm
SK2.22	2	4.0	2.5	3cold	1	2.0	3cold
SK3.04	11	22.0	2.6	2warm	5	10.0	2warm
SK3.11	16	32.0	3.6	1hot	9	18.0	1hot
SK3.13	8	16.0	3.6	1hot	5	10.0	2warm
SK3.18	16	32.0	3.3	1hot	6	12.0	1hot
SK3.20	20	40.0	3.4	1hot	8	16.0	1hot
SK3.21	10	20.0	3.2	2warm	4	8.0	2warm
SK3.23	3	6.0	1.3	3cold	1	2.0	3cold
SK3.24	19	38.0	2.8	1hot	7	14.0	1hot
SK3.31	7	14.0	2.6	2warm	4	8.0	2warm
SK3.32	11	22.0	3.5	1hot	5	10.0	2warm
SK3.33	15	30.0	2.6	2warm	5	10.0	2warm
SK3.35	5	10.0	2.6	3cold	2	4.0	3cold
SK4.03	3	6.0	3.0	3cold	2	4.0	3cold
SK4.15	3	6.0	1.3	3cold	1	2.0	3cold
SK4.16	3	6.0	3.0	3cold	0	0.0	3cold
SK4.25	9	18.0	2.7	2warm	3	6.0	2warm
SK4.26	2	4.0	2.5	3cold	1	2.0	3cold
SK4.27	4	8.0	2.3	3cold	3	6.0	3cold
SK4.29	5	10.0	3.4	2warm	3	6.0	3cold
SK4.30	4	8.0	2.8	3cold	0	0.0	3cold
SK4.31	6	12.0	2.7	2warm	3	6.0	2warm