Strange Matter
Summative Evaluation

Prepared for the
Materials Research Society

August 2004
Randi Korn & Associates, Inc.
118 E. Del Ray Avenue
Alexandria, VA 22301

p: 703.548.4078
f: 703.548.4306
www.randikorn.com

TABLE OF CONTENTS

LIST OF TABLES

SUMMARY AND DISCUSSION

This report presents the findings of a summative evaluation of *Strange Matter*, conducted by Randi Korn & Associates, Inc. (RK&A), for the Materials Research Society (MRS). *Strange Matter,* a traveling exhibition developed by the Ontario Science Center in partnership with the Materials Research Society, is funded by the National Science Foundation.

Data collection took place at the Liberty Science Center in Jersey City, New Jersey in March and April 2004. The evaluation documents the impact and effectiveness of the traveling exhibition and its associated Web site using timing and tracking observations, exit interviews, peer review, and telephone interviews with Web site users and non-users a few weeks after their visit to the exhibition.

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

METHODOLOGY

Timing and Tracking Observations

The evaluator observed a total of 115 walk-in visitors, ages 9 years and older. RK&A recorded the total time spent and the total stops made by observed visitors in the exhibition. Additionally, data for each exhibit were collected: the percentage of visitors that stopped, the median time, and the frequency of select behaviors (based on the exhibit's objectives).

Exit Interviews

RK&A conducted open-ended interviews with visitors immediately after their visit to *Strange Matter*. In all, 50 interviews were conducted with 101 visitors—53 adults and 48 children.

Peer Review

RK&A convened a peer review comprised of five museum professionals with experienced exhibition development and design. Reviewers met for a one-day critique of the exhibition framed by Serrell's guidelines.[1]

Telephone Interviews

RK&A conducted open-ended interviews with visitors a few weeks after they visited *Strange Matter* and agreed to visit the exhibition's companion Web site. In all, RK&A conducted 50 telephone interviews—25 with Web site users and 25 with non-users. RK&A randomly selected interviewees from a pool of 150 telephone numbers, collected by systematically intercepting visitors as they exited *Strange Matter*. RK&A staff gave those who agreed to participate in the study a card with the *Strange Matter* Web site URL and asked them to visit the Web site within two weeks.

[1] Serrell, B. (In press). *Judging Excellence: A Framework for Assessing Excellence in Exhibitions from a Visitor-experience Perspective*. Currently, the framework is available at www.msu.edu/~dillenbu/EJ/Framewk1117.pdf.

RESPONSES TO THE EXHIBITION

Overall, visitors said they enjoyed the experiences offered by the *Strange Matter* exhibition. Interviewees talked excitedly about interacting with old materials in new ways (e.g., Smash the Glass) or learning about new materials (e.g., ferrofluids). Peer reviewers also praised the exhibition for focusing on a unique topic for the museum field; providing visitors with opportunities to see interesting, real materials; and engaging visitors in fun activities.

Interviewees offered few criticisms of the exhibition. A few noted that particular exhibits were broken, not interesting, or confusing. A few other interviewees and some peer reviewers said the exhibition space was crowded and noisy, which negatively impacted their visit. Peer reviewers tended to agree that the exhibition was a bit dense—both in terms of text and experiences—making them feel somewhat overwhelmed by the stimuli. They acknowledged, however, that the exhibition's frenetic environment might appeal to children.

COMPARISON OF FINDINGS TO EXHIBITION GOALS

Strange Matter had mixed success in achieving MRS's stated outcomes (see Tables A and B). The interactives successfully engaged visitors and introduced them to the materials' properties. Interactives tended to attract the most visitors and hold their attention for the longest times. For example, 87 percent of visitors stopped at one or more interactives. Additionally, interactives fostered adult-child interactions, as 55 percent of families used interactives together. Most interviewees, including visitors interviewed over the telephone for the Web site a few weeks after their visit, said they enjoyed the exhibition. Additionally, when asked to discuss materials they experienced in *Strange Matter*, most interviewees had a richer sense of the diversity of materials compared with visitors in the front-end evaluation. Furthermore, the peer reviewers said the interactives and opportunities to engage with new materials were peak experiences.

The Materials Evolution was successful in terms of visitation but was less so in conveying the ethical issues related to materials science. More than one-half of visitors stopped in one or more of the four themes (food, clothing, tools, and identity). Most interviewees readily cited positive aspects of materials but had difficulty discussing the negative ones. Those who talked about environmental and other issues tended to use examples from prior knowledge rather than those from the exhibition. Peer reviewers suggested that the sheer density of information in Materials Evolution may have been a barrier to visitors' grasping the important issues.

The videos and Demonstration did not hold most visitors' attention and, as such, key exhibition messages, including who materials scientists are and how they work, were lost on most visitors. One-third of visitors watched one or more videos in their entirety. Only one visitor watched the Overview video. Interestingly, children stopped at more videos than did adults, suggesting that children may have been initially attracted to the medium or push-button start mechanism but lost interest in the video once it began playing. Some of the peer reviewers also found the videos to be uninteresting, poor production quality, and non-user friendly (videos could not be stopped once they began playing). In terms of the Demonstration, of the 18 visitors who attended it, three stayed to its conclusion. Visitors who participated in the Demonstration praised it, so its inability to hold visitors for the program's duration may be related to external issues rather than

poor content. For example, visitors' time constraints may have prevented their watching the entire program or competition with compelling interactives may have drawn them away from the Theater. A few interviewees noted that it was hard to hear the presentations in the Theater because of ambient noise, and this, too, may have contributed to few visitors staying to the end of the Demonstration and Overview video. Both the videos and Demonstration could have provided visitors with an orientation to the exhibition had more visitors attended these exhibits. Similarly, these exhibits might also have helped interviewees think about materials science in terms of processes and structure. However, when most interviewees defined materials science they focused on the materials' properties could not draw connections between how a material looks and behaves and how it was made. In fact, none of the interviewees talked about materials scientists.

Zoom, the pull-up-graphics, and the Introduction section were used by a minority of visitors and, again, because of this, visitors missed key exhibition messages. Zoom was used by less than one-third of visitors, while 14 percent of visitors used one or more pull-up graphics. Not surprisingly, no visitors understood scale. In fact, most interviewees who used Zoom said they thought it was simply about looking at magnified materials and did not discuss the different levels of magnification. Peer reviewers questioned the execution of Zoom and the scale pull-up graphics. They said they thought Zoom, like much of the exhibition, was too text heavy, that the "zoom in/zoom out" instructions were confusing, and that the differing scales were not obvious. They also noted that the small size, sliding feature, and placement of the pull-up graphics made them seem like detailed, tertiary information for highly motivated visitors rather than a unifying thread for the exhibition. In terms of the Introduction section, few visitors stopped at any of its exhibits: the Introduction element (What's This Exhibition About? panel), Overview Video, or Web site station. Peer reviewers expressed great concern about the exhibition's lack of a distinct and engaging Introduction. They said visitors' comfort would be greatly enhanced if the Introduction provided conceptual and physical orientation to help visitors see connections among the exhibits. They also said they thought the exhibition's main messages would be more effectively conveyed with a stronger Introduction. The fact that most interviewees perceived only two elements (properties and performance) of the materials science tetrad (properties, performance, structure, and processing) further substantiates the peer reviewers' comments.

While there were no specific outcomes for panels, it is worth noting that of all the exhibit types, panels were used the least often and held visitors' attention for the shortest times. In fact, several panels were completely ignored by all visitors observed. The low use of panels, along with the above-mentioned issues, likely contributed to visitors' missing some of the exhibition's important messages. Peer reviewers' suggested improvement for the exhibition's labeling to reinforce its main ideas included: reducing the amount of text on each panel; layering information to help visitors quickly glean each exhibit's essential ideas; replacing meaningless titles with ones that convey information, and creating new graphic standards to make each panel type more readily distinguishable.

Table A
Correlation of *Strange Matter* Outcomes and Observation Findings

Behavioral Outcomes	Outcome Achieved*	Supporting Findings
Visitors will stop at Zoom, Materials Evolution, and at least one exhibit cluster featuring a specific material (e.g., Ferrofluids).	Somewhat	30% stopped in Zoom, Materials Evolution, and one or more materials clusters.
Visitors will be drawn to the interactive exhibits and use them as designers intended.	Yes	87% stopped at one or more interactive exhibits. 47% used interactives as intended.
Families (multigenerational groups) will use the interactive exhibits together.	Yes	55% used interactives together.
Visitors will either visit the Introduction element or watch the Overview video in the Theater.	No	3% stopped at the Introduction element, and 1% stopped at the Overview video.
Visitors will stop at the Web site station in the Introductory Element.	No	11% stopped at the Web site station.
Visitors will watch at least one of the videos in its entirety.	Somewhat	33% watched one or more videos in their entirety.
Visitors will use one or more scale pull-up graphics.	No	14% used one or more pull-up graphics.
Visitors will stop at two or more of the Zoom stations.	Somewhat	30% stopped at two or more Zoom stations.
Adults will stop at and read at least one of the themes in Materials Evolution.	Yes	50% stopped at one or more Materials Evolution themes.
Visitors who attend the Demonstration will stay to its conclusion.	No	3 of the 18 visitors who attended the Demonstration stayed to its conclusion.

*Generally in quantitative museum evaluations, if one-half or more of visitors behave as intended, the outcome is considered to be achieved.

Table B
Correlation of *Strange Matter* Outcomes and Interview Findings

Experiential Outcomes	Outcome Achieved*	Supporting Findings
Visitors will have an enjoyable experience touching, testing, and observing a variety of familiar and unfamiliar materials.	Yes	Most interviewees said they enjoyed the exhibition. Some mentioned enjoying learning about new materials.
Visitors will be able to describe what Materials Science is and explain what materials scientists do. As stated in the exhibition, "Materials Science is the science of stuff. Materials scientists work with the tiniest bits of matter—molecules and atoms—to improve stuff or even create completely new materials that can do amazing things."	Somewhat	Most interviewees described materials science as the study of the properties and/or applications of materials. None discussed processing or scale.
Visitors will express a richer definition of "materials" as compared with the front-end evaluation. For example, they will note that the term encompasses more than fabric, building materials, and natural substances.	Yes	Most interviewees learned how a specific material such as tempered glass, silicon, etc., behaved or was made. Many interviewees discussed learning about materials, such as ferrofluids, that they had never heard of before visiting the exhibition.
Visitors will be able to describe a material using general concepts making up the materials science tetrad (properties, performance, structure, and processing). Adult visitors will be able to explain how the items in the tetrad are connected.	No	Most adults and all children could not draw connections between how a material looks and behaves and what is its structure and how it is processed.
Visitors will be able to better explain how a material's atomic structure affects the material's properties and performance as compared with the front-end evaluation. For example, visitors will note that different materials' atoms are arranged in a variety of ways and that arrangement affects how materials look and behave.	No	Most interviewees could not draw connections between how a material looks and behaves and its structure. The few who discussed structure used the same general terms that visitors in the front-end evaluation had used.
By visiting the Zoom exhibit, visitors will be able to explain that materials scientists study materials at different scales and identify one or more scales at which materials scientists work. Adult visitors will also be able to explain how and why some materials scientists study very small things.	No	Interviewees who visited Zoom did not grasp the different scales. They said they thought the exhibit was about looking at materials under a microscope to see what they look like up close.
By visiting Materials Evolution, visitors will be able to give one or more examples from the past, present, or future of how materials or material development (processing) play key roles in people's lives.	Somewhat	Many interviewees talked about the positive aspect of materials such as clothing, shelter, tools, etc.
Visitors to Materials Evolution will also be able to give one or more examples of the negative consequences and fallibilities of science and technology.	Somewhat	About two-thirds of interviewees cited potential negative aspects to materials; however, most gave examples not featured in the exhibition.
Visitors will be inspired and motivated to seek additional information about materials science as a result of their experience in *Strange Matter* (e.g., visit the *Strange Matter* Web site).	Somewhat	Most who used the Web site said it enhanced their experience of the exhibition. Non-users said the Web site should be promoted in the exhibition and incentives for using the Web site should be provided.

*Generally in qualitative museum evaluations, if many visitors respond as intended, the outcome is considered to be achieved.

VISITORS' RESPONSES TO THE WEB SITE

Web site users found the *Strange Matter* companion site enjoyable and easy to use. They praised the content for being information and interesting as well as accessible and appropriate for a range of audiences. Some also appreciated that the content related to their daily lives. Most Web site users also praised the Web site's design, favoring its colorful, child-friendly appearance. However, over one-half of Web site users encountered technical difficulties that negative impacted their experience: having to download software to view some of the features and download time.

Zoom, Transformer, and Materials Smack Down were the most popular features. Web site users liked these activities because of their humorous presentation and compelling content. Fewer visitors used the Change the World Challenge, as they thought it as for older children or found it text heavy. Few visitors used any of the resources or outside links either because they thought that information was more appropriate for teachers or because of time constraints.

Most Web site users felt the Web site had enhanced their experiences of the exhibition as it provided a self-paced way to learn more about things they saw in the exhibition. In fact, Web site users recalled more about the exhibition than did non-users. Furthermore, Web site users were four times more likely to say they learned something from the exhibition than non-users.

Non-users tended to dislike using the Internet, so their reasons for not visiting the *Strange Matter* Web site were personal rather than related to its content or execution. Non-users did suggest, however, that the Web site should be promoted more in the exhibition, including distributing take-home items (e.g., a magnet) with the URL.

RECOMMENDATIONS

- Consider reworking the Introduction section into a compelling exhibit experience that can help visitors understand the exhibition's main messages and layout of the space.

- Based on visitor behavior, the Theater cannot serve a primary role in the Introduction section. As such, consider providing more of an enclosed environment for the Theater—to mitigate noise and to encourage visitors to commit to the presentation rather than wandering in and out of the open space.

- Because revising the pull-up-graphics is likely cost-prohibitive, reference the scale pull-up-graphics in the Introduction section so that visitors know what they are and to look for them throughout the exhibition.

- Consider developing a portable version scale (bookmark, postcard, etc.) that visitors can take home with them. Include the Web site URL on this take-away item. To prevent waste, floor staff and Demonstration presenters could be responsible for distributing such items.

- Consider revising some key text panels, for example at Zoom and Materials Evolution, to help visitors quickly grasp important concepts such as scale and the costs/benefits of materials.

- Because revising the videos is likely not an option, focus on staffing the exhibition with real scientists from the community. MRS is already working hard to accomplish this—the evaluation provides greater justification for these efforts.

- Because it is unlikely that visitors will spend their time in *Strange Matter* using the Web site computer kiosk, encourage visitors to go to the Web site after they visit the exhibition by providing take-away items with the URL. These items could also be mailed to schools and other organized groups that are planning field trips, so that children have something concrete to take home with them to show their parents.

INTRODUCTION

This report presents the findings of a summative evaluation of *Strange Matter*, conducted by Randi Korn & Associates, Inc. (RK&A), for the Materials Research Society (MRS). *Strange Matter,* a traveling exhibition developed by the Ontario Science Center in partnership with the Materials Research Society, is funded by the National Science Foundation.

Data collection took place at the Liberty Science Center (LSC) in Jersey City, New Jersey in March and April 2004. The evaluation documents the impact and effectiveness of the traveling exhibition and its associated Web site, using timing and tracking observations, exit interviews, peer review, and telephone interviews with Web-site users and non-users a few weeks after their visit to the exhibition. The evaluation's specific objectives were to determine:

- To what degree the exhibition achieved its goals and objectives (see Appendix A for exhibition outcomes);
- How visitors use the exhibition;
- The meaning visitors constructed from their exhibition experiences;
- Visitor's affective and cognitive experiences;
- Web site users' responses to the exhibition's companion *Strange Matter* Web site;
- Barriers causing people to refrain from using the *Strange Matter* Web site;
- Whether using the *Strange Matter* Web site deepened visitors' understanding of the exhibition by comparing responses of Web site users and non-users; and
- Ways the *Strange Matter* Web site can extend the exhibition experience.

METHODOLOGY

RK&A used two data collection strategies to assess visitors' experiences in *Strange Matter*: timing and tracking observations and uncued exit interviews. Additionally, RK&A convened a peer review to provide MRS with feedback about the exhibition from museum professionals. To understand the relationship between the *Strange Matter* exhibition and its Web site, RK&A conducted telephone interviews. Additionally, RK&A convened a peer review of museum professionals to proved MRS with feedback about the exhibition.

Timing and Tracking Observations

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

All visitors 9 years of age and older were eligible to be unobtrusively observed in the exhibition. The e evaluator 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 observed the first eligible visitor to enter. The observer followed the selected visitor through the exhibition, recording the exhibits used, select behaviors, and total time spent in the exhibition

(see Appendix B for the observation form). When the visitor completed his or her visit, the observer returned to the entrance to await the next eligible visitor to enter the exhibition.

In addition to recording stops made and time spent at each exhibit, the data collector also noted specific behaviors listed on the observation form. One behavior was misuse of an exhibit—that is using an exhibit in ways not intended by the developers. Appendix C describes the intended use and misuse of exhibits.

Exit Interviews

Open-ended interviews encourage and motivate interviewees to describe their experiences, express their opinions and feelings, and share with the interviewer the meaning they constructed from an experience. Open-ended interviews produce data rich in information because interviewees talk about their personal experiences.

Upon exiting the exhibition, visitors nine years old and older were eligible to be selected (following a continuous random sampling method, as described above) to answer several questions about their experiences (see Appendix D for the exit interview guide). The interview guide was intentionally open-ended to allow interviewees the freedom to discuss what they felt was meaningful. All interviews were tape-recorded with participants' permission and transcribed to facilitate analysis.

Peer Review

RK&A convened a peer review comprised of five museum professionals with experience in exhibition development and design: Gretchen Jennings, Chief of Education at the Lemelson Center for the Study of Invention and Innovation, National Museum of American History, Smithsonian Institution (Washington, DC); Wayne LaBar, Vice President for Family Experiences at the Liberty Science Center (Jersey City, NJ); Kathleen McLean, Director of the Center for Public Exhibition at the Exploratorium (San Francisco, CA); Stephanie Ratcliffe, Vice President for Visitor Experience and Museum Operations at the Natural History Museum of the Adirondacks (Tupper Lake, NY); and Tim Wintemburg Senior Exhibit Designer at the Newark Museum (Newark, NJ).

The evaluator invited peer reviewers to view the exhibition and participate in a critical assessment on March 26, 2004. RK&A led the discussion, which was framed by Serrell's guidelines.[2] MRS representatives listened to the conversation and provided context. A note-taker recorded the conversation, and peer reviewers also submitted anonymous written statements describing their overall responses to the exhibition.

Telephone Interviews

For the Web site, the evaluator systematically intercepted visitors as they exited *Strange Matter, and* asked them to participate in a telephone interview about the Web site. Once a visitor agreed

[2] Serrell, B. (In press). *Judging Excellence: A Framework for Assessing Excellence in Exhibitions from a Visitor-experience Perspective*. Currently, the framework is available at www.msu.edu/~dillenbu/EJ/Framewk1117.pdf.

to participate, the evaluator game him/her a card with the Web site URL. Interviews about the Web site took place two to four weeks after those visits. One-half of interviewees had used the Web site and the other one-half had not (see Appendix E for the Web-site interview guide).

Only visitors 18 years old and older were approached for a telephone interview. The telephone interview guide was open-ended to allow individuals to express what they found meaningful about their visit. All interviews were tape-recorded with participants' permission and transcribed to facilitate analysis.

DATA ANALYSIS

Quantitative Analysis

The observational data were quantitative, and were entered into a computer to be analyzed statistically using SPSS/PC+, a statistical package for personal computers. Frequency distributions were calculated for all categorical variables (e.g., gender, age group). To examine the relationship between two categorical variables (e.g., use of an exhibit and age group), cross-tabulation tables were computed to show the joint frequency distribution of the two variables, and the chi-square statistic (X^2) was used to test the significance of the relationship.

Summary statistics, including the mean (average), median (data point at which half the responses fall above and half fall below), and standard deviation (spread of scores: "±" in tables), were calculated for the time data.[3] To compare the means of two or more groups, an analysis of variance (ANOVA) was performed. The level of significance was set at 0.05 because of the moderate sample size. When the level of significance is set to $p = 0.05$, any relationship that exists at a probability (p-value) of ≤ 0.05 is termed "significant." When a relationship has a p-value of 0.05, there is a 95 percent probability that the relationship being explored truly exists; that is, in 95 out of 100 cases, there really would be a relationship between the two variables (e.g., gender and preferences for visiting). Conversely, there is a 5 percent probability that the relationship does not really exist; in other words, in 5 out of 100 cases, a relationship would appear purely by chance. Within the body of the report, only statistically significant results are discussed.

Qualitative Analysis

The interview data are qualitative, meaning that results are descriptive, following from the conversational nature of the interviews. In analyzing the data, the evaluator studied responses for meaningful patterns, and as patterns and trends emerged, grouped together similar responses.

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

To illustrate interviewees' thoughts and ideas as fully as possible, verbatim quotations (edited for clarity) are included in this report.

METHOD OF REPORTING

The data in this report are both quantitative and qualitative. For the quantitative data, tables and graphs display the information. 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, for visitors, an asterisk (*) signifies the start of a different speaker's comments. Trends and themes in the interview data are also presented from most- to least-frequently occurring.

Findings in each report are presented in four main sections:

I. Timing and Tracking Observations
II. Exit Interviews
III. Web Site Telephone Interviews
IV. Exhibition Peer Review

I. PRINCIPAL FINDINGS: TIMING AND TRACKING OBSERVATIONS

The evaluators collected data at the Liberty Science Center over 11 days in March and April 2004, to coincide with spring break for public schools in the Jersey City area. The evaluators observed 115 walk-in visitors, ages nine years and older.

DATA COLLECTION CONDITIONS

Evaluators conducted the majority of observations on weekend days during moderate visitation conditions with few broken exhibits (see Table 1).

Table 1
Data Collection Conditions
(*n* = 115)

Condition	%
Day	
Weekend day	73.9
Weekday	26.1
Crowding Level	
Moderate	65.2
Crowded	23.5
Few	11.3
Broken Exhibits Encountered	
None	80.8
One	15.7
Two	3.5

VISITOR DEMOGRAPHICS

As shown in Table 2, the total sample of visitors observed included one-half males and one-half females (each 50 percent). Slightly more than one-half of visitors (54 percent) were adults (19 years of age and older) and slightly less than one-half were children 46 percent).

Table 2
Visitor Demographics
(*n* = 115)

Characteristic	Total %
Gender	
Male	50.4
Female	49.6
Age Group	
9 to 10 years old	12.2
11 to 12	18.3
13 to 15	11.3
16 to 18	4.3
19 to 24	0.9
25 to 34	24.3
35 to 44	20.0
45 to 54	4.3
55 years or older	4.3

As presented in Table 3, the majority of visitors in the sample were in groups of both adults and children (84 percent).

Table 3
Group Composition
(*n* = 115)

Group Composition	Total %
Adults and children	83.5
Adults only	7.0
Children only	6.1
Alone	3.5

OVERALL VISITATION PATTERNS

Total Time Spent in the Exhibition

Visitors spent a median of 13 minutes in *Strange Matter* (see Table 4). The shortest time a visitor spent in the exhibition was 44 seconds and the longest time was over 1 and one-half hours.

Table 4
Total Time Spent in *Strange Matter*
(*n* = 115)

Median	Minimum	Maximum	Mean	±
12 minutes, 58 seconds	44 seconds	1 hour, 38 minutes, 19 seconds	16 minutes, 28 seconds	14 minutes, 15 seconds

Total Number of Exhibits Stopped At

Strange Matter included 122 exhibits at which visitors could stop.[4] **For this evaluation, a "stop" was defined as a visitor standing for three seconds or longer in front of a component. If a visitor returned to a component at which s/he had previously stopped, this return was not counted as an additional stop, but the amount of time spent was included in the total time spent at the component.**

Visitors stopped at between 1 and 52 exhibits in *Strange Matter* (see Table 5). Visitors stopped at a median of 10 exhibits (8 percent of the exhibits available).

Table 5
Total Number of Exhibits Stopped at in *Strange Matter*
(*n* = 115)

Median	Minimum	Maximum	Mean	±
10.0	1.0	52.0	12.5	10.1

[4] The Theater included two exhibits: the video introduction and the demonstration. The Foam phenomenon also included two: staffed and unstaffed.

VISITATION TO EACH EXHIBITION SECTION

Strange Matter included 12 sections: Introduction Area, Nitinol, Tempered Glass, Magnetic Fluids, Silicon, Amorphous Metals, Foam, Defects, Crystals, Touch Table, Zoom, and Materials Evolution (see Appendix B for the timing and tracking form). To understand the relative use of each section, the total time spent and total number of stops in each section were calculated.

Total Number of Sections Visited

Visitors stopped at a median of five sections while in *Strange Matter* (see Table 6). Nearly one-half of visitors stopped at six or more exhibition sections (47 percent; not shown in table).

Table 6
Total Number of Sections Visited in *Strange Matter*
(*n* = 115)

Median	Minimum	Maximum	Mean	±
5.0	1.0	11.0	5.2	2.9

Stops Made in Materials Sections

Eight of the sections—Nitinol, Tempered Glass, Magnetic Fluids, Silicon, Amorphous Metals, Foam, Defects, and Crystals—deal with specific materials important to materials science. As shown in Table 7, about 84 percent of visitors stopped in one or more of the materials sections.

Table 7
Percentage of Visitors Stopping in Materials Sections
(*n* = 115)

Stops in Materials Sections	%
Stopped in one or more materials sections	84.3
Did not stop in one or more materials sections	15.7

Time Spent and Stops Made in Each Section

More than one-half of visitors stopped in the Touch Table, Tempered Glass, and Materials Evolution sections (approximately 69 percent, 67 percent, and almost 56 percent, respectively) (see Table 8). The fewest visitors stopped in the Introduction Area and Silicon sections (27 percent and about 25 percent, respectively).

Visitors spent the most time in the Introduction Area (median time of about 4 minutes), followed by the Touch Tables (median time of about 3 minutes). Visitors spent the least time in the Crystals and Silicon sections (median times of 42 seconds and 30 seconds, respectively).

Visitors stopped at the most exhibits in the Touch Table section (median of 4 exhibits). Visitors stopped at one exhibit in each of the following sections: Tempered Glass, Amorphous Metals, Defects, Introduction Area, and Silicon.

Table 8
Time Spent and Stops Made in Each Section

Section	% Visitors Stopping	Median Time (Seconds)	Median Number of Stops
Touch Table	68.7	179.0	4.0
Tempered Glass*	67.0	121.0	1.0
Materials Evolution	55.7	69.5	2.0
Magnetic Fluids*	47.0	136.5	2.0
Crystals*	40.9	42.0	2.0
Zoom	40.9	121.0	3.0
Foam*	39.1	53.0	3.0
Amorphous Metals*	38.3	77.5	1.0
Defects*	36.5	55.0	1.0
Nitinol*	34.8	95.5	2.0
Introduction Area	27.0	260.0	1.0
Silicon*	25.2	30.0	1.0

*Eight of the sections feature a specific material.

Eight of the sections dealt with a specific material. A specific behavioral outcome of the exhibition was that visitors stop in at least one materials section, Zoom, and Materials Evolution. As shown in Table 9, 30 percent stopped in all three of these sections.

Table 9
Percentage of Visitors that Stopped in At Least One Materials Section, Zoom, and Materials Evolution
(*n* = 115)

Sections Visited	%
Stopped in at least one materials section, Zoom, and Materials Evolution	30.4
Did not stop in all three	69.6

Materials Evolution and Zoom were large sections comprised of several subsections. Materials Evolution included four themes: tools, food, clothing, and identity. One-half of visitors stopped at one or more of the themes (50 percent) (see Table 10). Zoom was comprised of six subsections (the subsections are delineated on the tracking form in Appendix B). More than two-thirds of visitors stopped in fewer than two subsections (70 percent) (see Table 11).

Table 10
Percentage of Visitors that Stopped at One or More Themes in Materials Evolution
(*n* = 115)

Sections Visited	%
Stopped at one or more themes	50.4
Did not stop at one or more themes	49.6

Table 11
Percentage of Visitors that Stopped in Two or More Zoom Subsections
(*n* = 115)

Sections Visited	%
Did not visit two or more subsections	69.6
Visited two or more subsections	30.4

When the time spent and stops made in each section were examined by demographic characteristics and data collection conditions, the evaluator found three statistically significant relationships (see Tables 12 and 13). Children spent more time and stopped at more exhibits in the Touch Tables Section than did adults. Children also spent more time in the Tempered Glass section than did adults.

Table 12
Differences in Time Spent and Stops Made in the Touch Tables Section by Demographic Characteristics
(*n* = 79)

Age Group[1]	Mean Time (Seconds)	±
Child	280.0	169.3
Adult	176.5	159.5
Age Group[2]	**Mean Stops**	**±**
Child	5.4	2.6
Adult	4.1	2.3

[1] $F = 7.625$; $df = 1, 78$; $p = 0.01$ [2] $F = 5.363$; $df = 1, 78$; $p = 0.02$

Table 13
Differences in Time Spent and Stops Made in the Tempered Glass Section by Demographic Characteristics
(*n* = 77)

Age Group[1]	Mean Time (Seconds)	±
Child	184.6	140.3
Adult	103.3	97.4

[1] *$F = 8.931$; $df = 1, 76$; $p = 0.00$

VISITATION OF EACH EXHIBIT TYPE

The exhibition included 10 types of exhibits: panel, panel with objects, flip panel, pull-up-graphic, interactive, video, staffed exhibit, object/magnifier, phenomenon, and computer interactive. To understand the relative use of each exhibit type, the total time spent and the total number of stops at each exhibit type were calculated.

Time Spent and Stops Made at Each Exhibit Type

As shown in Table 14, 87 percent of visitors stopped at interactives. More than one-half stopped at panels with objects, at video, and at objects/magnifiers (63 percent, 55 percent, and 52 percent, respectively). The fewest visitors stopped at the pull-up-graphics and the computer interactive (14 percent and 13 percent, respectively).

Visitors spent the most time at staffed exhibits and interactives (median total time of about 4 minutes). They spent the least time at panels and pull-up-graphics (median total times of 22 seconds and 13 seconds, respectively).

In terms of the number of stops visitors made at each exhibit type, visitors made the most stops at interactives (median of 7 stops). Visitors stopped at a median of one video, object/magnifier, panel, phenomenon, staffed exhibit, and pull-up-graphic.

Table 14
Time Spent and Stops Made at Each Exhibit Type

Exhibit Type	Number of Exhibits Available	% of Visitors Stopping	Median Time (Seconds)	Median Number of Stops
Interactive	22	87.0	383.0	7.0
Panel with objects	14	62.6	62.0	2.0
Video	8	54.8	43.0	1.0
Object/magnifier	10	52.2	25.0	1.0
Panel	41	34.8	21.5	1.0
Flip panel	10	32.2	51.0	3.0
Phenomenon	2	21.7	30.0	1.0
Staffed exhibit	2	18.3	629.0	1.0
Pull-up-graphic	12	13.9	13.0	1.0
Computer interactive	1	11.3	29.0	N/A

When the time spent and stops made at each exhibit type were examined by demographic characteristics and data collection conditions, two statistically significant relationships were found (see Tables 15 and 16). Children spent more time at interactives and stopped at more videos than did adults.

Table 15
Differences in Time Spent at Interactives by Demographic Characteristics
(*n* = 100)

Age Group*	Mean Time (Seconds)	±
Child	726.1	553.0
Adult	444.6	435.7

*$F = 8.109$; $df = 1, 99$; $p = 0.01$

Table 16
Differences in Stops Made at Videos by Demographic Characteristics
(*n* = 63)

Age Group*	Mean Number of Stops	±
Child	2.0	1.2
Adult	1.4	0.7

*$F = 7.993$; $df = 1, 62$; $p = 0.01$

VISITATION OF INDIVIDUAL EXHIBITS

Tables 17 and 18 below show the exhibits at which visitors spent the most and least time. See Appendix G for the relative time rankings of the remaining exhibits.

Tables 19 and 20 in the second section show the exhibits at which the most and least visitors stopped. See Appendix H for the relative visitation rankings of the remaining exhibits.

Time Spent at Each Exhibit

Table 17 shows the 20 exhibits at which visitors spent the most time (i.e., exhibits that had the longest dwell times). Visitors spent the most time in the Theater—either during a showing of the introduction video or the demonstration (median times of about 12 minutes and 11 minutes, respectively). The Smash the Glass interactive, the Can you Hot Wire a Hole in One? interactive, and View the Materials 200 times interactive held visitors' attention for nearly two minutes each.

Table 17
Twenty Exhibits with the Longest Dwell Times

Exhibit	Number of Visitors Stopping	Median Time (Seconds)
Theater introduction video	1	731.0
Theater demonstration	18	663.0
Smash the Glass interactive	75	106.0
Can You Hot Wire a Hole in One? interactive	29	100.0
View the Materials 200 times interactive	26	100.0
Want to Feel Something Really Weird? interactive	29	97.0
Can you Find the Supermetal? interactive	38	85.5
Opals May Someday Supercharge the World panel	1	75.0
It's a Scope on a Rope interactive	41	69.0
Iceman panel/object	10	65.5
Please Walk on the Flowers interactive	26	64.0
MR Fluids and You panel	2	62.0
Xactly What is Happening with This Xylophone? panel	2	61.5
Xylophones interactive	40	61.5
Ferrofluids and You panel	1	59.0
Nitinol's A Shifty Character panel	2	58.0
What's Growing Here? phenomenon	20	58.0
Manipulate this Liquid (Ferrofluids) interactive	38	56.5
How's It Shaking? interactive	33	56.0
Much Ado about (Almost) Nothing panel	3	51.0

As shown in Table 18, the exhibits at which visitors spent the least time are Got an Eye for Detail panel, How Small are Atoms? Panel, Food panel/objects/push button, and Sea Sponge flip panel (median times of 4 seconds, 4 seconds, 2 seconds, and 2 seconds, respectively).

Table 18
Twenty Exhibits with the Shortest Dwell Times*

Exhibit	Number of Visitors Stopping	Median Time (seconds)
Opal 10,000x's pull-up-graphic	2	9.5
Aluminum flip panel	16	9.0
Aerogel flip panel	10	9.0
Explore Opal's Essence magnifier	18	9.0
Ordinary or Tempered Glass? panel/object	5	8.0
Ferrofluids pull-up-graphic	1	8.0
Silicon's Secret panel	1	8.0
Stem flip panel	9	8.0
History: 1600s Microscope object	4	8.0
Opal 50x's pull-up-graphic	2	7.5
Does Heating the Wire Move the Arm? panel	1	7.0
Chipping Away at Silicon panel/object	4	7.0
What is 10x's Harder than Steel panel	5	7.0
Amorphous Metal and You panel/object	6	7.0
Going with the Grain magnifier	16	7.0
This Baby is Big? panel	2	7.0
Got an Eye for Detail panel	1	4.0
How Small are Atoms? panel	1	4.0
Food panel/objects/push button	27	2.0
Sea Sponge flip panel	10	1.5

*No visitors stopped at 14 exhibits: Nitinol pull-up-graphic, How is Glass Made Tougher? panel, What is the Breaking Point of Glass? panel, MR Fluids pull-up-graphic, Silicon and You panel, Foam and You panel, Defects and You panel, Defects pull-up-graphic, Explore Some Handy Materials panel, Landscapes of the Microworld panel, Opal 1000x's pull-up-graphic, You're Looking at . . . panel, How do You See Stuff That's Invisible? panel, and Zoom in on Atoms panel.

Stops Made at Each Exhibit

Table 19 shows the 20 exhibits at which the most visitors stopped (i.e., exhibits that had the strongest attraction power). The most visitors stopped at the Smash the Glass interactive, followed by Which Materials Have Magnetic Personalities? interactive, Weird Waterfalls interactive, and Flowing Glass interactive (65 percent, 44 percent, 39 percent, and 39 percent, respectively).

Table 19
Twenty Exhibits with the Strongest Attraction Power

Exhibit	% Stopping
Smash the Glass interactive	65.2
Which Materials Have Magnetic Personalities? interactive	43.9
Weird Waterfalls interactive	39.1
Flowing Glass interactive	39.1
It's a Scope on a Rope interactive	36.3
Xylophones interactive	34.8
Can you Find a Smooth Ride? interactive	33.9
Been There, Seed That interactive	33.9
Manipulate this Liquid (Ferrofluids) interactive	33.0
Can you Find the Supermetal? interactive	33.0
Light Table interactive	31.3
Use the Magnet to Move the Fluid interactive (tabletop)	30.4
How's It Shaking? interactive	28.7
Tour a Miniature Crystal Garden interactive (2)	28.7
Clothing panel/object/touchable object	28.7
Identity panel/object/push button	27.2
Can You Hot Wire a Hole in One? interactive	25.2
Want to Feel Something Really Weird? interactive	25.2
Silicon Ingot and Wafers object/touchable object/magnifier	25.2
Food panel/objects/push button	23.5

One visitor (1 percent) stopped at each of 16 exhibits—most of which were stand alone panels (see Table 20).

Table 20
Twenty Exhibits with the Weakest Attraction Power*

Exhibit	% Stopped
Slip Sliding Away panel	1.7
Got an Eye for Detail panel	1.7
Opal 50x's pull-up-graphic	1.7
Opal 10,000x's pull-up-graphic	1.7
Theater introduction video	0.9
Does Heating the Wire Move the Arm? panel	0.9
Ferrofluids pull-up-graphic	0.9
Ferrofluids and You panel	0.9
For Ferrofluids Size Matters! panel	0.9
Silicon's Secret panel	0.9
The Harder the Surface panel	0.9
Aerogel pull-up-graphic	0.9
A Case of Comparing Crystals – Salt panel/object	0.9
A World of Magnets panel	0.9
Looks Can Be Deceiving panel	0.9
Opal 10x's pull-up-graphic	0.9
History: 1900s Microscope object	0.9
Opals May Someday Supercharge the World panel	0.9
Down, Up, and Atom panel/object	0.9
How Small are Atoms? panel	0.9

*No visitors stopped at 14 exhibits: Nitinol pull-up-graphic, How is Glass Made Tougher? panel, What is the Breaking Point of Glass? panel, MR Fluids pull-up-graphic, Silicon and You panel, Foam and You panel, Defects and You panel, Defects pull-up-graphic, Explore Some Handy Materials panel, Landscapes of the Microworld panel, Opal 1000x's pull-up-graphic, You're Looking at . . . panel, How do You See Stuff That's Invisible? panel, and Zoom in on Atoms panel.

BEHAVIORS

Use of Interactives

Of the 96 visitors attending the exhibition in a multigenerational group, about 55 percent used interactives together (see Table 21). See Appendix I for details about social interactions at each interactive.

Table 21
Percentage of Visitors Using Interactives as a Multigenerational Group
(*n* = 96)

Use of Interactives	%
As a multigenerational group	55.2
Not as a multigenerational group	44.8

Data collectors noted when visitors misused interactives—that is, used them in ways the developers did not intend (see Appendix C for definitions of exhibit misuse). Of the 100 visitors who used interactives, 53 percent misused one or more interactives during their visit (see Table 22). See Appendix J for details about misuse at specific interactives.

Table 22
Percentage of Visitors Misusing Interactives
(*n* = 100)

Misuse of Interactives	%
Misused one or more interactives	53.0
Did not misuse any interactives	47.0

Use of Pull-up-graphics and Flip Panels

Data collectors also noted when visitors misused pull-up-graphics and flip panels (see Appendix C for definitions of exhibit misuse). Of the 37 visitors who used pull-up-graphics and/or flip panels, 27 percent misused one or more of these exhibits during their visit (see Table 23).

Table 23
Percentage of Visitors Misusing Pull-up-graphics and/or Flip Panels
(*n* = 37)

Misuse of Pull-up-graphics and/or Flip Panels	%
Did not misuse any pull-up-graphics and/or flip panels	73.0
Misused one or more pull-up-graphics and/or flip panels	27.0

Video Watching

Of the 63 visitors who watched videos, 33 percent watched one or more videos to completion (see Table 24). See Appendix K for details about video watching at specific exhibits.

Table 24
Percentage of Visitors Watching Entire Videos
(*n* = 63)

Watching Entire Videos	%
Did not watch any videos to completion	66.7
Watched one or more videos to completion	33.3

Participation on a Demonstration

Of the 18 visitors who stopped in the Theater during a demonstration, three watched the entire program and two participated in the lab (see Table 25).

Table 25
Number of Visitors Participating in the Demonstration
(*n* = 18)

Demonstration Participation	*n*
Watched part of the demonstration	15
Watched entire demonstration	3
Did not participate in lab	16
Participated in lab	2

Interactions with Staff

Data collectors noted when visitors interacted with staff either at the two exhibits designed to be periodically staffed (Theater demonstration and Foam phenomenon) or elsewhere in the exhibition. Most visitors did not interact with staff (86 percent) (see Table 26).

Table 26
Percentage of Visitors Interacting with Staff
(*n* = 115)

Staff Interactions	%
Did not interact with staff	86.1
Interacted with staff one or more times	13.9

II. PRINCIPAL FINDINGS: EXIT INTERVIEWS

RK&A evaluators conducted open-ended interviews with visitors immediately after their visit to *Strange Matter* at LSC to gather information about their perceptions, opinions, and understanding of the exhibition. Evaluators conducted 50 interviews with 101 visitors—53 adults and 48 children. Of 72 visitors approached, 22 refused to participate, a typical refusal rate for museum studies of 31 percent.

Slightly more than one-half of adults were female and slightly less than one-half were male. In contrast, more than one-half of children were male and slightly less than one-half were female. The median age of adults was 40 years and children was 12 years.

One-half of interviewees had visited LSC before the day of the interview, while the other one-half were visiting LSC for the first time. Nearly all were visiting *Strange Matter* for the first time. More than one-half of interviewees were aware of the *Strange Matter* exhibition before they visited LSC that day. Many had learned about the exhibition from television commercials, while some others read about it on LSC's Web site.

OVERALL REACTIONS TO *STRANGE MATTER*

When the evaluators asked interviewees their overall opinion of *Strange Matter*, most interviewees said that they enjoyed the exhibition. Some described it as educational, appreciating learning about new things (see the first three quotations below). Others also praised its interactive nature, and a few said that the exhibition worked particularly well for children (see the fourth and fifth quotations).

> I thought it was great! I thought it was great because you got to learn a lot of stuff. It's different from all the other exhibits in the museum. [Male, 14 years]
>
> I enjoyed it. I've always been very interested in materials engineering and seeing some of the new technologies that are emerging and how you present them so that people can just understand them is nice. It's not very well understood—the engineering discipline—to most lay people but the way you describe it makes it very understandable. [Male, 39 years]
>
> I like going into the things you wouldn't think about normally and so it's kind of cool, it shows you things you would never think about. I thought it was really cool. [Female, 12 years]
>
> It's fun! Because I liked how . . . a lot of it was just hands-on things, what you can do, hit the glass and have fun. [Male, 12 years]
>
> It's good for kids, it's nice and it's different for kids. [Female, 34 years]

Interviewees made a few critical comments about *Strange Matter* relating to exhibit components not working properly (see the two quotations below).

> A couple of things were broken though, but . . . you can't control that with little kids I guess, you know, using the stuff. [Female, 42 years]

> Some of the stuff doesn't work . . . . You want to [do it and] you get really excited about it—the description that it has—and then it doesn't work. [Female, 10 years]

MOST AND LEAST FAVORITE EXHIBITS

The evaluators asked interviewees to identify their most and least favorite exhibits and to explain their choices. Some interviewees said they found the magnet exhibits—including the ferrofluids—most interesting (see the first quotation below). Some others expressed surprise by Smash the Glass (see the second quotation). Several interviewees were intrigued by the cultural section which included the Iceman and different types materials used for clothing and tools (see the third quotation). A few said they enjoyed the demonstration the most (see the fourth quotation).

> I liked the magnets - the ferrous fluid with the magnet stuff. It was pretty good. (Why did you like that?) Just because it makes different designs. *[The designs] just pop up out of nowhere. [Male, 38 years; Female, 45 years]

> (Of all the things you did in this exhibition, what was the most fun or interesting?) Probably the one where you smacked the thing in the ball and it just comes really fast down [Smash the Glass]. I was expecting the glass to [break] and shatter into a billion pieces – and it didn't. It was real amazing! [Male, 12 years]

> The exhibit with the iceman . . . that was really interesting. I'd read about that before, but [it] was interesting to see what he wore and different materials [he used]. [Female, 48 years]

> I love the lectures that the guy does [the demonstration]. We watched the whole thing . . . where he demonstrated the force per square inch to crush something and the memory metal and how it can spring back. [Female, 72 years]

Many interviewees said they appreciated particular exhibits because they learned something new from them (see the first and second quotations below). Some said they enjoyed seeing examples of unusual materials, while others liked the interactive nature of particular exhibits (see the third and fourth quotations).

> I never knew that there were liquid magnets before! [Female, 13 years]

> The gentleman explaining how a silicon wafer is made was really good. I didn't know anything about that before he told me. [Male, 48 years]

> Not that I understand it, but just to see the liquid magnetized . . . was [cool]. [Male, 65 years]

> [The tempered glass] only breaks so often. So it's really exciting. You really want to know if you're going to break it or not, because you can interact with it [and] you could actually do it. [Female, 11 years]

When asked about their least favorite exhibit, many interviewees did not have a least favorite. A few said they found the microscopes uninteresting (see the first quotation below). Others had idiosyncratic dislikes, noting that a particular exhibit was broken, "boring," or confusing to understand. A few also noted that the exhibition space was crowded and noisy which negatively impacted their visit (see the second quotation).

> With this magnification or that, they were just talking about this one that showed different . . . matter and the magnification was not great, it was like four to [one]. . . And then you look[ed] through a microscope and the microscope said it was only five times. That's not much of a difference. [Male, 35 years]

> [It was] very hard to hear the introductory movie because it's so noisy in here today. The noise and crowds make things not so enjoyable. [Female, 48 years]

MAIN IDEA OF *STRANGE MATTER*

When the evaluators asked interviewees to describe *Strange Matter*'s maid ideas, many said the exhibition was about "matter" or "materials" (see the first quotation below). Some of these interviewees noted that materials are processed and used in different ways (see the second and third quotations). A few interviewees used the term 'material science' to describe the exhibition (see the fourth quotation).

> Different kinds of matter or different things like the sponges. [Female, 72 years]

> [It's] about how matter is different and how different matter [is] affected in different ways by different forces on [it]. [Male, 14 years]

> Progress—from what it was many years ago to what it is today. How some things evolved from just simple forms through to complex products. Like the silicon. We were looking at the silicon. Just amazing, just the compound of sand and the products they make out of it. [Male, 44 years]

> Well, material science, very practical concept of the science in daily [life], applying daily observation. [Female, 30 years]

In contrast, some interviewees did not discuss material science as a main idea of *Strange Matter*. Several said that the exhibition was about science and how scientists do their work (see the

quotation below). A few interviewees said it was about history, mentioning the Iceman or the chain mail armor in the exhibition.

> I think the exhibit has a chance [to] talk about scientific process, like the process of mak[ing] observations, different types of observations, properties and new ways, as any kind of scientist wants to take a look at when you think you have something new. [Male, 35 years]

DEFINITION OF MATERIALS SCIENCE

Later in the interview, the evaluators asked interviewees to define "materials science." Most described material science as the study of the behavior, appearance and/or applications of materials (see the first three quotations below). Some interviewees said materials science was simply about "materials" with no further explanation given (see the fourth quotation). A few interviewees said that they did not know how to describe materials science.

> It's like why the materials stay together and it has something to do with friction. [Male, 12 years]

> Probably the study of, working with, I think that we reuse the word in the definition, but without going through naming them specifically, how different materials can come together and how we can use them to make things. And what, hopefully, effects those have on our world, whether they be good or bad. [Male, 37 years]

> Material science is the science, the study of materials, the parts of the material, the property of material, and then how it can be applied. [Female, 31 years]

> I would say materials, I think of materials. [Female, 12 years]

DISCUSSION OF DIFFERENT MATERIALS

The evaluators asked interviewees what they had learned about materials in the exhibition. The evaluators also asked interviewees to talk about the materials they examined in the exhibition, including their behavior and appearance.

New Knowledge about Materials

Most interviewees said they learned how a specific material such as tempered glass, silicon, metals, or magnets behaved or how it was created (see the first three quotations below). Some interviewees said they learned about the uses of materials (see the fourth quotation). A few interviewees said they learned what materials looked like through magnification.

> I guess I never really knew what tempered glass was and what it was actually, how they made it stronger then actual glass—so that was something new. (How did they do that?)

> They layer it with a different kind of material, I forgot exactly what it was, but that's what they do. [Female, 47 years]
>
> I didn't know silicon was an artificial crystal—a very wide, large crystal. [I didn't know] that you could make it very wide. [Male, 35 years]
>
> [I learned that] aluminum is not magnetic. [Male, 14 years]
>
> I didn't know about ferrofluids. I learned that and NASA [used] ferrofluids to transfer fuel from . . . one unit to another in outer space. I thought that was really clever. So a lot of our innovative uses are coming to pass by way of the military or NASA or both. [Female, 72 years]

Experiences with Specific Materials

Nearly all interviewees recalled examining different kinds of materials; however, most were unable to draw a connection between the way a material looks and behaves and its structure and processing. Interviewees frequently talked about examining ferrofluids. Most simply noted that the liquid was magnetic (see the first quotation below). A few explained that a liquid's magnetic properties owe to its tiny iron particles (see the second quotation).

> We looked at the magnet liquid stuff. . . . The kids were playing with it and making it go [in] different directions. (What makes that liquid behave the way it does?) Because it's magnetic. (Anything about what it's made of that might make it magnetic?) It's just magnetic. [Female, 39 years]
>
> The ferrofluids, the iron crystals added [to] it . . . made them obviously receptive to magnets which I had known about, but it was still interesting to see the way you can move fluid, move it around the flat surface using a magnet because that's [iron has] been added. [Female, 72 years]

Many visitors also discussed examining wood and foams at the Scope-on-a-Rope, Xylophone, and Aerogel exhibits. While several noted that foams (called "plastics" by visitors) have different properties, they could not explain what might cause the different properties (see the first quotation below). In contrast, one interviewee said that plastics behave the way they do because of the way the molecules are linked together, while another interviewee said that it had to do with the way the plastic was processed and how much air was added to the material. Those interviewees who examined wood said that it makes different sounds depending on the type and length of the wood (see the second quotation).

> Different plastics behave differently. Some are resilient, some have insulating effects and things like that. (What causes different plastics to behave in different ways?) I don't know. They behave different ways so they're used in different things. [Male, 65 years]

> The shorter bars [on the xylophone] made a higher pitched noise, the longer bars made a lower sound. (Anything else about the bars that might change its sound?) Maybe the type of wood [they are made of.] [Male, 15 years]

Some interviewees talked about how tempered glass breaks in a different way than regular glass, but were unsure why it does (see the first quotation below). Some others mentioned watching crystals grow, one of whom said crystals differ in appearance because of their structure (see the second quotation). A few discussed examining nitinol but were uncertain how it remembers its shape (see the third quotation). One interviewee talked about amorphous metals, noting that the way their atoms are organized makes them strong metals (see the fourth quotation).

> [The tempered glass] breaks safely. It breaks into small pebbles not into sharp, razor sharp pieces. (Why might tempered glass break in a different way from regular glass?) I don't know. [Male, 11 years]

> I looked at the crystal growing. (So, why does the crystal look the way it does?) Because the molecules align differently depending on what the material is, they have their own specificity. [Female, 30 years]

> [The metal] bends back because of the structure and when there's a lot of pressure on it, on the metal, it starts to bend but it springs back into form when there's no pressure on it. [Male, 14 years]

> Because it's metal on metal . . . its shape sticks. It's like atoms on atoms. [Male, 12 years]

POSITIVE AND NEGATIVE ASPECTS OF MATERIALS

The evaluators asked interviewees to discuss both the positive and negative aspects of materials, throughout human history and in the future.

Interviewees tended to discuss exhibits or information in the Materials Evolution section of the exhibition. For example, many said a positive aspect of materials is their ability to protect people by being used for either clothing or shelter (see the first and second quotations below). Some interviewees mentioned improvements in products throughout time such as tools or containers (see the third quotation). Others identified the durability of materials or the development of the silicon chip as positive impacts of materials.

> Well, they protect people. Like the chain mail for instance, it keeps them [safe], it keeps the arrow from [hitting] them. [Male, 10 years]

> Well some of them, like the issues with the skier or the snowboarder—the helmet for example—some materials allow for protection. Also the glass, the tempered glass that would break so you wouldn't get hurt. Really great compared to normal glass. [Female, 48 years]

> Well, because the products that [the exhibition] hasn't shown, I mean amazing today, just the simple thing of the design of the cans for food, I mean think about how much they've evolved in the past 30 or 40 years alone. [Now] they're made of aluminum. Years ago they weren't made of aluminum, they were made of tin. Aluminum doesn't rust. I think it's a better product, it's a better overall container than what it was. [Male, 44 years]

Interviewees had more mixed responses about materials' negative aspects. About two-thirds of interviewees cited potential negative aspects to materials, while the remaining one-third said there were no negative aspects to materials. When interviewees did discuss the negative aspects of materials, their responses were less specific to the exhibition and more aligned with prior knowledge. For example, several interviewees said that materials have the potential to pollute the environment but gave examples not included in Materials Evolution (see the first two quotations below). A few said that materials could be used to create devices that could potentially hurt or kill people such as nuclear weapons (see the third quotation).

> There should be more electric cars because then the air wouldn't be so dirty and there would be less viruses. [Male, 11 years]

> [There are problems] only in the case of stuff that's toxic materials that we just saw on television, the computers that were thrown out are in the dump that release lead, and come to find [out], there's mercury leaking. [Female, 60 years]

> Well the nuclear [bomb] stuff probably. [Male, 17 years]

SCALE

The evaluator asked interviewees to talk about their use of the exhibition's Zoom section to determine whether they gleaned any information about scale. One-half of interviewees visited Zoom, while one-half did not. Of those who visited Zoom, many said that the section was about how different materials like fabric or hair look close up (see the first and second quotations below). Several interviewees said the section was about looking at the structures of materials or what materials are made of (see the third and fourth quotations). A few said they did not know what Zoom was about.

> How the different materials looked underneath the microscope, some were more spongyish looking. [Male, 10 years]

> Learning to see what's in it [materials] and what it looks like up close. [Male, 13 years]

> You can actually see the actual structure. If you take a look at polystyrene you can actually see the ribwork inside holding the polystyrene together. [Male, 63 years]

> [It was about] the molecules from the thing you're looking at. [Male, 11 years]

When asked what Zoom had to do with materials, many interviewees who used Zoom said it showed the composition and properties of materials (see the quotations below). A few said Zoom was to allow visitors to look at different materials—from hair to wood—under the microscope.

> Well it showed…what things looked like. It showed . . . what the fibers look like that things are made of. [Female, 38 years]

> It was about looking at materials, finding out what its properties are—like that it stretches—by just looking at it. [Female, 21 years]

III. PRINCIPAL FINDINGS: EXHIBITION PEER REVIEW

RK&A convened a peer review with five museum professionals with experience in the exhibition development and design: Gretchen Jennings, Chief of Education at the Lemelson Center for the Study of Invention and Innovation, National Museum of American History, Smithsonian Institution (Washington, DC); Wayne LaBar, Vice President for Family Experiences at the Liberty Science Center (Jersey City, NJ); Kathleen McLean, Director of the Center for Public Exhibition at the Exploratorium (San Francisco, CA), Stephanie Ratcliffe, Vice President for Visitor Experience and Museum Operations at the Natural History Museum of the Adirondacks (Tupper Lake, NY); and Tim Wintemburg, Senior Exhibit Designer at the Newark Museum (Newark, NJ).

Peer reviewers were invited to view the exhibition and participate in a critical assessment on March 26, 2004. Serrell's guidelines[5] framed the discussion which RK&A led. Representatives from MRS listened to the conversation and provided context. A note-taker recorded the conversation, and peer reviewers also submitted anonymous written statements describing their overall responses to the exhibition (see Appendix L for the reviewer's memos).

OVERALL REACTIONS TO STRANGE MATTER

Overall, reviewers said *Strange Matter* featured interesting materials, many of which they had never seen before, and included several highly engaging exhibits. They described the exhibition as "cool," praising it for having "lots of fun things to do," and "lots of real stuff." While reviewers' opinions about individual exhibits differed, the Manipulate this Liquid ferrofluid exhibit was often mentioned as an interesting exhibit because it is visually striking and it provides visitors the opportunity to play with a new material. A few also liked exhibits that allowed visitors to compare and handle different materials such as the Scope-on-a-Rope interactive, foam examples with flip panels (e.g., bread, sea sponge), and the Light Table interactive. Smash the Glass was one of the more controversial exhibits: three reviewers questioned its concept and found its noise level distracting, while two others praised its value as an exhibit icon and its appeal to visitors.

While reviewers said they thought *Strange Matter* would engage visitors, they offered some criticisms of the exhibition. All reviewers said the exhibition was too text-heavy and lacked a text/graphics hierarchy to help visitors find the most important messages. They said the number of panels and the number of words on each panel could be significantly reduced while still providing adequate information. For example, a few referred to Materials Evolution as a "tunnel of text." Additionally, reviewers could not distinguish between the different types of panels. For example, they had looked for the introduction panels for each cluster to understand what that area was about, but could not find them. In a related comment, reviewers said the placement of panels was often confusing. They noted that at some exhibits, information pertinent to an interactive was placed far from the interactive, decreasing the likelihood that visitors would read

[5] Serrell, B. (In press). *Judging Excellence: A Framework for Assessing Excellence in Exhibitions from a Visitor-experience Perspective*. The framework is available at www.msu.edu/~dillenbu/EJ/Framewk1117.pdf.

the information. Two reviewers said the panels' titles sacrificed clarity for the sake of humor, noting that the "cute" titles did not convey any exhibit content.

Reviewers could not determine the exhibition's organizational structure and wondered why it lacked a designated introduction section. When MRS staff explained that there is an introductory area with an introduction panel and the theater with the overview video, none of the reviewers had used these components. Reviewers also said that the exhibits, while interesting on their own, did not tie back to a central, coherent idea—at least not one obvious to them. When MRS shared the exhibition's main message, reviewers said they thought the exhibits conveyed the idea that there are a variety of interesting materials each with different properties; however, they said the exhibition's organization and panel titles could better convey the other main ideas. Additionally, none of the reviewers had paid attention to the scale pull-up-graphics. They said the size and nature of the pull-up-graphics suggested that this was detailed information for highly motivated visitors and not central to the exhibition.

Reviewers found a few exhibits difficult to use or of poor quality. Two could not locate the levers at the Manipulate this Liquid and Want to Feel Something Really Weird? ferrofluids exhibits. They also complained that Want to Feel Something Really Weird? was poorly designed, and encouraged visitors to misuse the exhibit by smearing the gray ferrofluid on the viewing window. Two reviewers criticized the videos. They said the production value of the videos was low and noted that the user interface required pushing a button to see captioning and did not allow visitors to stop a video once it started. One reviewer was frustrated by the How's it Shaking? interactive, stating that she did not understand what it was trying to teach visitors.

SERRELL'S FOUR CRITERIA FOR ASSESSING EXCELLENCE IN EXHIBITIONS

Serrell uses four criteria for assessing excellence in exhibitions from a visitor-experience perspective: whether the exhibit is comfortable, engaging, reinforcing, and meaningful. These criteria framed reviewers' assessments of the exhibition. First, reviewers used Serrell's worksheet and gave an individual rating for each criteria, then they had a discussion so that the group could come to consensus about the ratings. Rather than reporting numerical ratings, the findings are presented in narrative to illustrate reviewers' comments.

Comfortable

Serrell states, "An excellent exhibition helps visitors feel comfortable—physically and psychologically. Good comfort opens the doors to other positive experiences. Lack of comfort prevents them."

The reviewers rated *Strange Matter* as minimally "comfortable" for visitors. Reviewers agreed that the lack of physical and conceptual orientation would likely prevent visitors from having a comfortable experience in the exhibition. Some added that the noise level of certain exhibits and general "frenzied" atmosphere prevented relaxation and reflection. However, these same reviewers noted that children might find this kind of environment appealing. A few cited the lack of seating as a barrier to visitor comfort.

Engaging

Serrell states, "An excellent exhibition is engaging for visitors. It entices them to pay attention. Engagement is the first step toward finding meaning."

The "engaging" criterion received the most positive remarks from reviewers. All praised the exhibition topic for being unique and interesting. They were intrigued by many of the materials, especially the ferrofluids and aerogel. Most said they felt the exhibition offered a good variety of exhibit types that would appeal to a range of visitors and plenty of interactive exhibits to use. Some also said the interactives would encourage social interactions among family members. A few criticized the audio visual presentations for being "boring talking heads." Others said visitors would have little motivation to read because the panels were too text heavy and there were simply too many panels in the exhibition.

Reinforcing

Serrell states, "In an excellent exhibition, the exhibits provide visitors with abundant opportunities to be successful and to feel intellectually competent—beyond the 'wow' of engagement. In addition, the exhibits reinforce each other, providing multiple means of accessing similar bits of information that are all part of a cohesive whole. Visitors are confidently well on their way to having meaningful experiences."

Reviewers had mixed feelings about whether *Strange Matter* was "reinforcing." Some said its clusters of exhibits focusing on one material reinforced the idea that the exhibition was about diverse materials with different properties. However, all said that the more complex ideas of structure, processing, and scale were not obvious threads connecting the exhibit clusters. Similarly, reviewers said they felt the connections between Zoom, Materials Evolution, and the rest of the exhibition were rather weak. One reason for their assessment was that they were confused by Zoom, and did not realize that different scales were featured and did not understand the "zoom in/zoom out" instructions. Another reason they offered for their perceived weak connections was they did not pay attention to the "Materials and You" panels or the scale pull-up-graphics. Reviewers did not realize there were different types of panels, remarking that the graphic treatments of the all the panels looked very similar. Nor did they realize that the scale pull-up-graphics were information important sources. The small size and pull-up feature of these panels made them seem like "tertiary-level" information and not primary to the exhibit experience. Reviewers agreed that better layering of information—including making each panel type more readily distinguishable—and a more obvious introduction area that could provide conceptual and physical orientation, would have made the exhibition more reinforcing.

Meaningful

Serrell states, "An excellent exhibition provides personally relevant experiences for visitors. Beyond being engaged and feeling competent, visitors find themselves changed, cognitively and affectively, in immediate and long-lasting ways."

Reviewers also had mixed reactions to whether *Strange Matter* was "meaningful." A few said that while they had gained greater insight into the field of materials science, the exhibition did not touch upon any universal concerns, change their perspective, or connect with them in a deep way. For example, they said they felt the Materials Evolution was a "march of progress" rather than an unbiased, thought-provoking assessment of the impact of materials. Others wondered whether "meaningful"—as defined by Serrell—was an appropriate criterion for the exhibition, asking if MRS intended to provide visitors with "transcendent" experiences. One of these reviewers said that simply introducing children to the field of material science and creating positive science experiences makes *Strange Matter* meaningful. Another said that the exhibition might make a visitor more aware of the material world around them and that would be a different way of looking at one's environment.

SUGGESTION FOR CHANGE

At the discussion's conclusion, reviewers offered suggestion for improving *Strange Matter*. All suggested revising the introduction to be a compelling exhibit experience to help visitors understand the exhibition's main messages and the layout of the space as well as improving the labeling throughout the exhibition to reinforce its main ideas. A few suggested revising all the panels—reducing the amount of text on each panel, replacing "cute," meaningless titles with ones that convey information, and creating new graphic standards that make each panel type more readily distinguishable.

IV. PRINCIPAL FINDINGS: WEB SITE TELEPHONE INTERVIEWS

RK&A conducted open-ended telephone interviews with visitors within a few weeks after they visited the *Strange Matter* exhibition at LSC to gather responses to the exhibition's accompanying Web site, identify barriers to using the Web site, and determine whether the Web site enhanced the exhibition experience.

The evaluator collected telephone numbers in March and April 2004 by intercepting visitors 12 years old and older as they exited the *Strange Matter* exhibition and asking them to participate in a telephone interview in a few weeks. Upon agreeing, visitors provided their telephone numbers, were given the Web site URL and asked to visit the *Strange Matter* Web site. Of 183 visitors approached, 133 refused to participate in the study, making a refusal rate of 73 percent, a relatively high rate for museum studies but similar to refusal rates RK&A experienced during another evaluation using telephone interviews.

For the telephone interviews, phone numbers were randomly selected from a pool of 150 until 50 telephone interviews were conducted—25 interviewees who had used the Web site at the time of the interview (Web site users) and 25 interviewees who had not (non-users). During random selection, 15 visitors who were called did not remember visiting the exhibition, so those interviews were terminated.

BACKGROUND INFORMATION ABOUT INTERVIEWEES

Slightly more than one-half of interviewees were male and slightly less than one-half were female. Their median age was 36 years.

Two-thirds of interviewees had visited LSC before the day of the interview, while the other one-third was visiting for the first time.

Interviewers asked Web site users to rate their experience using the Internet—"inexperienced," "somewhat experienced," or "very experienced." Twelve said they were "very experienced" at using the Internet, 10 said they were "somewhat experienced," and three rated themselves "inexperienced" at using the Internet.

REPORTED USE OF WEB SITE

Use with Others

Most Web site users said they used the Web site alone. Some used it with their children, who ranged in ages from four to eleven years old. A few said they planned to show the site to their children. One added that her children enjoyed using the Web site (see the quotation below).

> My kids enjoyed [using the Web site]. It gave us insight and got them psyched to see the exhibit. When I saw that they were interested, I [decided] that's what we would do for the day. [Web site user, Female, 36 years]

Home Page Features Used

Strange Matter's Web site's home page included four features: Zoom, Transformer, Materials Smack Down, and the Change the World Challenge. Two-thirds of Web site users visited two or more of these features. Two-thirds used Zoom; one-half used the Materials Smack Down and/or Transformer; and one-quarter used the Change the World Challenge.

Web site users said that Zoom, Transformer, and the Materials Smack Down worked well and that they enjoyed using them (see the first quotation below). None of the users reported any problems using these features. Web site users were less interested in the Change the World Challenge. They found it to be text heavy and more appropriate for older children than the other features (see the second quotation below).

> I think my favorite is the Zoom one. . . I think that was a really novel way to show something, to explain a very difficult concept to a child in a very visual way that they'll remember. [Web site user, Male, 31 years]

> (What was your least favorite part of the Web site?) Probably Change the World. It might have been over [my children's] heads. I don't think it was bad, I just think it was just not on their age level. [Web site user, Female, 36 years]

Web site users offered various reasons for choosing particular features. Several said they chose ones that piqued their interest or seemed more eye-catching (see the first quotation below). Several others said they tried all of the links to get an overview of the Web site—either to satisfy curiosity (see the second quotation), or to be well-informed for the interview (see the third quotation). A few users said they chose particular links to view more information about topics they saw in the exhibition (see the fourth quotation). Finally, one user said she selected Zoom because she felt it was designed for younger children—like those in her family.

> I tried Change, the Smack Down, and the Zoom. (Why did you decide to use those activities?) Just based on the icons on the bottom, they looked interesting. [Web site user, Male, 31 years]

> I tried them all out of curiosity to see if I knew something about it. . . . It was actually more out of curiosity than anything else, because I just didn't know what [the Web site] included. [Web site user, Male, 40 years]

> I think I just previewed them all. (Why did you decide to do all of them?) Because you were going to be calling me and I wasn't sure what parts you were going to want to talk about. [Web site user, Male, 39 years]

> [I did] Zoom and the Materials Smack Down. (Why did you choose to use those activities?) Because in the exhibit, some of those were shown and I liked those and I wanted to experiment [with them]. [Web site user, Male, 14 years]

Many Web site users said they skipped links because they had limited time to explore the Web site (see the first quotation below). A few opted not to look at some links because they took a long time to load (see the second quotation). A couple said they did not visit Change the World because they were not drawn to it and/or felt it was not age appropriate (see the third quotation).

> I tried to get to all of them. . . The only one I didn't get to was [Change the World]. I worked from left to right, so the [Change the World] part kind of got the last of my attention. I could see that happening with the kids, too. [Web site user, Female, 51 years]

> We skipped [Zoom and Change the World] mostly because of the time factor, because . . . it took so long for them to load. [Web site user, Male, 40 years]

> The Smack Down was my kids' favorite. (What do you think they liked most about it?) They're 4 and 6 [years old]. Anything that's part of something that's broken, smashed, that's what they go for. They just think it's cooler than saving the world [in Change the World]. [Web site user, Female, 36 years]

Links/Resources Used

When asked which links or resources they visited, the majority of Web site users said they did not visit any. A few visitors said they did not have enough time to visit the links, but intended to do so (see the first quotation below). A few said they looked at the resources, but did not use them. One visitor explained that after looking at one link, she concluded that they were more for school use than personal use (see the second quotation below).

> We looked at a couple of [the resource links], but we didn't do any of them yet. But we might go back and try some of these things on a weekend when we have some time to mess around with them. [Web site user, Female, 38 years]

> I clicked on one of the [resource] links and I didn't find it terribly productive. . . I thought it was a good idea to have them there. . . I think it would be a good adjunct for a school or science class. [Web site user, Male, 48 years]

OVERALL OPINION OF WEB SITE

The evaluator asked Web site users a series of questions to gauge their opinion of the Web site—they discussed their favorite and least favorite items and gave their opinion about the level of information provided. Users were also asked to recount any frustrations they experienced—such as navigation problems and downloading software.

Content

Nearly all Web site users commented positively about the content of the *Strange Matter* Web site. Many described it as "informative" and "interesting." Some recommended the site to others (see the first quotation below). Moreover, most praised the level of the site's content, saying they found the information accessible and appropriate for a range of audiences (see the second quotation). However, a couple said the Web site was text heavy and time consuming to use (see the third quotation).

> [My son and I] both liked it. I think my son's going to want to go back and check out some of the things we didn't spend time playing with. . . My wife says he told her that she should go there and see if there's anything that fits into what she's doing. [Web site user, Male, 38 years]

> I thought it was very good. It seemed to have a lot of information and it was presented in a pleasant manner and a manner that appealed to a wide span of ages . . . and it was fairly easy for my son to navigate. [Web site user, Female, 40 years]

> We weren't really impressed. I thought there could have been more to it, especially a science type of Web site. . . We just found printed materials and it wasn't that exciting. It was just like a one-time thing and that was enough for us. [Web site user, Male, 33 years]

Web site users discussed a range of features they enjoyed: some discussed Zoom, followed by the Materials Smack Down, and Transformer (see the first quotation below). Several others said the activities on the Web site explained the exhibition content and connected it to their daily lives (see the second quotation).

> The Materials Smack Down was cool. I remember that. . . I always thought it was interesting to learn about different properties of the materials and how they hold up and how they can change. And then I remember they were squishing everything. So you know, squishing things is fun. I remember once I did the first one, I was like, this is cool. I was doing the other ones to see what kind of reaction the other materials would have. And I like the Transformer, because I was curious as to how they used the materials and how they change it, how they add other materials and make something completely different. [Web site user, Female, 28 years]

> When you do the experiments on the Web site, it teaches you what actually happened [with what you saw at the Science Center]. At the *Strange Matter* [exhibition] I didn't

> really feel like reading them, but at home I got to read them. . . I liked the [Materials Smack Down] where if you choose two things and have them together, what will be the outcome? That was interesting. (Why do you think that was so interesting?) Because I really didn't know what was [going to win] from the two different things. Maybe because, at the time, I had a chemistry project to do, and so I went [to the Web site] and it actually helped me with my homework. So it was very helpful to me. [Web site user, Male, 13 years]

Several Web site users said they found the content of particular activities and links—such as the Change the World Challenge and the resource links—"boring" or lacking in detail (see the quotations below).

> The only thing that I found boring was the press kit area, and the actual material science page that looked at all the different things. And that's a shame because that particular page has a lot of really good information on it. But I think most people aren't going to read that, especially that incredible amount of text. [Web site user, Male, 31 years]

> You know what I was a little disappointed on? The one where I clicked on something, where they're looking for cures for cancer? [Change the World Challenge] That one I wasn't too thrilled with. (Okay, why was that?) I actually thought that was going to go into more depth than it did. [Web site user, Female, 39 years]

Design

Two-thirds of Web site users did not encounter any difficulties with the Web site's design—many said it was simple to use, and several commented that the Web Pages were well designed and colorful (see the quotation below).

> I like [the Web site], I like the colors. . . It's very playful. It makes you do things, like click here, click there, and it's not boring. You want to click here and find out a little more. I thought that the presentation is very nice and eye catching, and it wasn't boring at all. [Web site user, Female, 40 years]

In contrast, a few Web site users indicated that some aspect of the design negatively impacted their experience. Users listed font size and the amount of text on the Web site as problematic (see the first quotation below). In addition, a few said that Materials Research Scientist testimonials seemed out of place or out of synch with the design of the rest of the Web site (see the second quotation).

> I think there's way too much text on the Web site. And it's small print. . . [I would change] the small font. I'm getting too old. [Web site user, Male, 39 years]

> (What was your least favorite thing on the Web site?) The page where it explained the different types of materials. I think it's called the material science page, where it showed a picture and it gave a paragraph of explanation. I think that it just loses the flavor, it doesn't go with the rest of the Web site. (How could it be improved?) It needs to be

> more graphical, the rest of the Web site is very graphic, kid-oriented. It's almost like you go from kid to adult. And I think most kids would click on it, look at it, and go, "oh, boring, a whole page of text. I'm not reading this, adios." [Web site user, Male, 31 years]

Technical Issues

Over one-half of Web site users encountered technical difficulties that negatively impacted their experience. More specifically, some users reported that many of the Web site's features, such as the flash introduction and interactive activities, took a long time to download (see the first quotation below), and several added that the length of time spent downloading information or activities prevented them from using some of the components (see the second quotation).

> (What, if anything, was frustrating or problematic about using the Web site?) I don't like downloading all the macromedia. I don't download any extra if I don't have to. I like to try to keep it to a minimum of different files downloaded due to viruses. [Web site user, Male, 46 years]

> For me it was a little cumbersome because of the loading time on all these items, so I wasn't able to go to every single piece [of the Web site]. It just took too long for me. [Web site user, Female, 40 years]

IMPACT OF WEB SITE ON THE EXHIBITION EXPERIENCE

The evaluator asked Web site users and non-users a series of similar questions, and their responses were compared to assess the impact of the Web site on the exhibition experience. The evaluator asked Web site users and non-users to discuss their recollections of the *Strange Matter* exhibition, and what they learned from their experiences in the exhibition (and from the Web site). Additionally, the evaluator asked them to discuss any topics or ideas from the exhibition (and Web site) they had thought about since their visit.

Recollections of the Exhibition

Most interviewees described the exhibition as "easy to understand," "interesting," and some added that it worked well for their children. As one said, "[*Strange Matter*] is the one that my children and I thought was really good." However, Web site users recalled more about *Strange Matter* than non-users—approximately two-thirds of users remembered two or more components, while over one-half of non-users recalled one or fewer components.

Overall, interviewees said they enjoyed nearly all the same aspects of the exhibition: most said they enjoyed using one or more of the physical interactives, including Smash the Glass and the ferrofluids exhibits. Web site users and non-users had similar reflections about their *Strange Matter* experiences. Many said they had thought about specific exhibit components such as Smash the Glass and the silly putty demonstration (see the first quotation below). A few said the exhibition prompted thoughts about science in general (see the second quotation). Finally, a few applied their *Strange Matter* experiences to other contexts (see the third and fourth quotations).

> My daughter and I watched the Silly Putty demonstration . . . we actually talked about it a couple of times since then. We kind of argued back and forth whether [Silly Putty] was a solid or not. [Web site user, Male, 31 years]
>
> It's really interesting to think about the stuff that we have in daily life and what we really don't pay attention to, like what [things] are made of and how we could preserve [them]. [Non-user, Female, 20 years]
>
> There was this exhibit where if you put the heat on it became liquid, and if it didn't have the heat on it became mush. . . It was almost like my son was fascinated with that because it was almost like the movie Terminator II. If you remember, that guy in the movie became liquid. [Non-user, Male, 35 years]
>
> My son plays baseball and they just got these new baseball bats that have liquid metal in them. Supposedly you can hit the ball further because of the metal in the bat. I said, "Oh, it must have something to do with that principle we saw in *Strange Matter*." [Non-user, Male, 46 years]

Content of Strange Matter Exhibition

There were some differences in what Web site users and non-users said they learned about material science from their experiences. Web site users were four times more likely than non-users to say they learned something from *Strange Matter*. Web site users mentioned specific facts or ideas that they learned from the exhibition and Web site (see the first two quotations below). Some also noted that they now have a greater appreciation for materials after visiting the *Strange Matter* exhibition and Web site (see the third quotation).

> I [learned] that tempered glass can be hard to break. I learned how different materials sort of look similar under a microscope and have different properties. [Web site user, Male, 48 years]
>
> What did I learn? That materials aren't always what they appear to be. . . And there are a lot of new materials now that do things that you wouldn't expect them to do. [Web site user, Female, 37 years]
>
> [I learned] a couple of things about the different materials that I didn't realize we used for everyday items. I didn't realize, for instance, that silicon was used. I didn't relate sand to silicon to be used for cell phones and that type of deal. [Web site user, Male, 40 years]

More than one-half of non-users said that they did not learn anything new from their experiences (see the quotation below). In contrast, some non-users noted that the exhibition gave them a new appreciation for everyday materials. A few said they learned about the strength and/or behavior of specific materials, such as spider webs and tempered glass. Others had idiosyncratic responses, saying they learned how to use a microscope, what hair looks like up close, and how

parachutes work. In addition, one non-user said, "I learned that I need to see an exhibit before I take students."

> For me it was kind of a review. I mean in a funny way, all that kind of thing is a review of stuff that you knew once when you were young or you were taught and you didn't pay attention [to], or you were taught it and you were interested, but then you forgot it. [Non-user, Male, 39 years]

When the evaluator asked Web site users and non-users what topics or ideas from the exhibition and Web site they had reflected on since their visit, few differences emerged. More than one-half of users and non-users said they had not thought about the exhibition or the Web site after their experiences. One-quarter of users and one-fifth of non-users said that they had thought about a specific exhibition and/or Web site component—Smash the Glass, silicon/sand, Transformer—displayed in the exhibition and on the Web site (see the first quotation below). A few Web site users and non-users said they thought about what things are made of (see the second quotation) and/or science in general (see the third quotation).

> The bowling ball and the glass [Smash the Glass] just popped into my head because it was fun. Like with the Transformer on the site itself, when I learn something like that, that sand can be mixed with other things and turned into something else. Something like that just pops into my head for no reason whatsoever, just because I remember the experiment. [Web site user, Male, 28 years]

> It certainly makes me look at things differently, . . . in the sense of what they're made of and how they're constructed molecularly. It makes you pay more attention to the matter of things, the make-up of things. [Web site user, Male, 38 years]

> I don't know if I thought about anything in particular. Just the idea that science is an everyday idea, that everything we use is extracted from science. [Web site user, Female, 46 years]

Web Site's Relationship to Exhibition Experience

The evaluator told Web site users that the Web site's purpose is to enhance visitors' exhibition experience. The evaluator asked visitors to discuss how visiting the Web site after seeing the exhibition impacted them, and how the site could be changed to compliment their exhibition experience.

Web site users voiced different opinions about the degree to which the Web site extended their exhibition experience, if at all. Three-quarters of Web site users said the Web site enhanced their experience in some way. Many said that the Web environment provided time to reflect and explore at their own pace (see the first and second quotations below). A few said the Web site's design provided more of a learning opportunity for them and for children (see the third and fourth quotations). A few said the Web site enhanced their experience by providing additional information not available in the exhibition. As one user said, "the Web site told me more about what I didn't know during the exhibit. I went to the Web site, I learned more."

> I know going to the exhibit itself was more hands on as opposed to explaining how materials change. That was more fun for me. But I wasn't really paying attention to things of that nature at the exhibit. It was more just let's play with this and see what it does. Whereas on the site, I was more into learning about materials and properties. To me it's almost like two separate things. It depends on what you're going to the exhibit for. It depends on the children you're with and what you're explaining to them. [Web site user, Female, 28 years]
>
> (In what ways if any did visiting the website after visiting the exhibits change how you thought about the exhibition of the information in the exhibition?) Well actually learning more, because I paid more attention to the Web site. During the exhibition, I was with the young children and they were really running around and they like touching everything without you really looking much into it. [Web site user, Male, 34 years]
>
> I think that the Web site was better than the actual exhibit itself, because I probably learned more on the Web site in ten minutes than I learned at the exhibit itself. And I think that's because of the way the exhibit was laid out. They didn't totally bring you into the whole exhibit, like the Web site did. [The Web site] is laid out in a way that really entices you to look through the entire Web site. [Web site user, Male, 31 years]
>
> [Visiting the Web site] definitely enhanced [the experience]. I'm sure there were things in the exhibit that were of good educational value, but for some reason they didn't really have the appeal to make the kids come over and take the time to look and learn about the material. But the animated nature of the Web site and the way it kind of relates to the way kids look at video games and animated things does. That would probably pull them to look at the information in a way that they would like it presented, so that they would probably be more attracted to learn it at the Web site than they would be from certain aspects of the exhibit. [Web site user, Female, 51 years]

In contrast, one-quarter of Web site users said visiting the Web site did not impact their exhibition experience. A few said too much time had passed between visiting the exhibition and using the Web site for them to connect the two. Others said they thought the two experiences were distinct and separate.

Web site users offered a range of suggestions for ways the Web site could better extend the exhibition experience. Some indicated that addressing the technical issues, such as slow loading times, would encourage visitors to use the Web site more thoroughly once they logged on (see the first quotation below). Several users said the Web site should explicitly reference the exhibition and vice versa (see the second quotation). A few others suggested adding more specific exhibit components to the Web site, such as the magnifier and the demonstrations (see the third quotation). While none of the users utilized the resources provided through the Web site links, a few said that the resources, such as the family guide, could extend the exhibition experience (see the fourth quotation).

(How might the Web site be changed so that it provides an experience that complements the experience visitors have with the exhibits?) By making it easy to get in to. I don't know if I didn't react fast because I don't have DSL or because it's just slow or my computer was very slow that day, which it generally isn't. But I found it way too time-consuming. [Web site user, Male, 62 years]

I think you should be able to show the Web site at the exhibit itself. I think that they complement each other by proximity. . . If we were able to get to the Web site at the exhibit, or even see screen shots of the Web site at the exhibit, or somehow draw more attention to the Web site, or incorporate the Web site into the exhibit. That's where it can entice the kids to want to learn more. [Web site user, Male, 31 years]

I wasn't able to go to the video part of [the Web site], so I don't know if you show any of the demonstrations from the exhibit. That might be nice to have as well. Repeat some of those demonstrations. . . It might be kind of nice to have little videos through some of the demonstrations with the children. [Web site user, Female, 40 years]

The thing I got out of it is that there were other resources that I could go to if I need to. If my son asks more questions or wants more information, there were resources for parents. I think there's actually a guide you can download. I thought that might be helpful for us in the future. [Web site user, Male, 40 years]

BARRIERS TO WEB SITE USE AND SUGGESTIONS TO IMPROVE IT

Web site users and non-users mentioned several reasons they would not have used or did not use the *Strange Matter* Web site. Several—including a few who used the Web site—said they do not like using the Internet other than e-mail, and would never have looked at the Web site without being referred to it for the evaluation (see the first quotation below). A few said they were simply not computer people (see the second quotation). A couple said that technical problems with their personal computers prevented them from using the Web site.

Usually if I go on the computer it's to do a specific thing and then I'm off. I don't really surf the Web very much. I check my e-mail and then I get off. . . Someone actually came up to me and handed me [a piece of paper with the Web site]. I probably wouldn't have known to even look for a Web site unless I had been given that piece of paper. [Non-user, female, 46 years]

I just don't want to go on [the computer] that much, to be quite honest. . . I'm not one of those computer people. I like to feel and see as opposed to just reading about it. [Non-user, Female, 44 years]

The evaluator asked non-users how the exhibition could encourage visitors to visit the Web site. Over one-half of non-users said the Web site need to be advertised more in the exhibition, and some added that the exhibition should provide the URL on handouts for visitors to take home (see the first and second quotations below). Others had idiosyncratic suggestions, such as giving

away IMAX tickets to Web site visitors and adding games. A few suggested posting clues or questions throughout the exhibition that could be answered on the Web site (see the third quotation).

> I don't remember seeing anything about [the Web site in LSC]. A little more display about a Web site would . . . make it more apparent to visitors. [Non-user, female, 46 years]

> [The exhibition] could give me a flyer or a postcard, or maybe a magnet. If I had a little magnet that I could put on my refrigerator . . . that would really jog my memory to go get on the computer. [Non-user, Female, 36 years]

> [To get people to visit the Web site] they could put questions in the exhibit and then you would have to go on the Web site to answer the questions. [Non-user, Male, 21 years]

APPENDICES

Appendix A
***Strange Matter* Exhibition Intended Visitor Outcomes**

Experiential Outcomes

- Visitors will have an enjoyable experience touching, testing, and observing a variety of familiar and unfamiliar materials.

- Visitors will be able to describe what Materials Science is and explain what materials scientists do. As stated in the exhibition, "Materials Science is the science of stuff. Materials scientists work with the tiniest bits of matter—molecules and atoms—in order to improve stuff or even create completely new materials that can do amazing things."

- Visitors will express a richer definition of "materials" as compared with the front-end evaluation. For example, they will note that the term encompasses more than fabric, building materials, and natural substances.

- Visitors will be able to describe a material using the general concepts that make up the materials science tetrad (properties, performance, structure, and processing). Adult visitors will be able to explain how the items in the tetrad are connected.

- Visitors will be able to better explain how a material's atomic structure affects the material's properties and performance as compared with the front-end evaluation. For example, visitors will note that different materials' atoms are arranged in a variety of ways and the arrangement affects how materials look and behave.

- By visiting the Zoom exhibit, visitors will be able to explain that materials scientists study materials at different scales and identify one or more scales at which materials scientists work. Adult visitors will also be able to explain how and why some materials scientists study very small things.

- By visiting Materials Evolution, visitors will be able to give one or more examples from the past, present, or future of how materials or material development (processing) play key roles in people's lives.

- Visitors to Materials Evolution will also be able to give one or more examples of the negative consequences and fallibilities of science and technology.

- Visitors will be inspired and motivated to seek additional information about materials science as a result of their experience in *Strange Matter* (e.g., visit the *Strange Matter* Web site).

Behavioral Outcomes

- Visitors will stop at Zoom, Materials Evolution, and at least one exhibit cluster featuring a specific material (e.g., Ferrofluids).
- Visitors will be drawn to the interactive exhibits and use them as designers intended.
- Families (multigenerational groups) will use the interactive exhibits together.
- Visitors will either visit the Introduction element or watch the Overview video in the Theater.
- Visitors will stop at the Web site station in the Introductory Element.
- Visitors will watch at least one of the videos in its entirety.
- Visitors will use one or more scale pull-up graphics.
- Visitors will stop at two or more of the Zoom stations.
- Adults will stop at and read at least one of the themes in Materials Evolution.
- Visitors who attend the Demonstration will stay to its conclusion.

APPENDIX B
MRS *Strange Matters* Timing and Tracking Observations
Removed for Proprietary Reasons

APPENDIX C
Strange Matter Intended Use of Interactives

General

Exhibit	Misuse	Intended Use
All flip panels	Flip panels randomly; do not look at results	Deliberately flip panels and look for results.
All pull out graphics	Pull out randomly or do not pull out at all	Pull out graphics and look at information deliberately

Introduction Area

Exhibit	Misuse	Intended Use
Website	Click randomly	Deliberate looking, clicking, searching

Tempered Glass Cluster

Exhibit	Misuse	Intended Use
Smash the Glass	Messing around with lever	Crank lever; press release button; and/or flip yes/no panels

Magnetic Fluids Cluster

Exhibit	Misuse	Intended Use
Want to Feel Something Weird?	Do not press button to activate magnet	Insert hands in gloves; hit button to activate magnet; play with/push around FF
Manipulate this Liquid (Ferro fluids)	Messing around with levers without observing what happens	Move one or two magnet levers deliberately and observe
Use the Magnet to Move the Fluid	Use incorrect end of magnet	Use correct end of magnet to move fluid and observe

Nitinol Cluster

Exhibit	Misuse	Intended Use
Please Walk on the Flowers	Aim heat at flowers but do not hold in one spot long enough to observe changes	Press button to activate; aim heat at flowers and stems deliberately; observe
Can You Hot Wire a Hole in One?	Mess around with hot-cold controls and buttons randomly without observing what happens	Manipulate hot-cold controls deliberately to move the arms over the marble; and/or press button to grab marble.

Defects Cluster

Exhibit	Misuse	Intended Use
How's It Shaking? w/5 panels	Sit on panels; shake or tilt without looking closely	Tilt or shake panels and look closely; and/or compare the two panels

Touch Table Cluster

Exhibit	Misuse	Intended Use
It's a Scope on a Rope	Do not use scope or magnifier to examine objects; use scope but do not look at monitor	Pick up and examine objects; use scope to look at materials and notice on monitor; and/or examine objects with magnifier
Xylophones	Play with one xylophone	Play with more than one xylophone or compare with another visitor
Can you Find a Smooth Ride?	Push only one disk along surfaces	Experiment with pushing different disks on different surfaces.
Light Table	Look at samples without trying different angels; organize samples on table	Pick up and hold at least one sample at different angles to notice changes
Open the Window	Slide wheels in and out without looking through them; spin wheels randomly; climb on	Slide wheels in one at a time and look through; and/or look through both wheels at the same time
Which Materials Have Magnetic Personalities?	Do not slide magnets over objects	Slide magnets over objects and observe
Weird Waterfalls	Flip one tube only or flip tubes randomly without observing	Flip both tubes and observe
Been There, Seed That	Flip one tube only or flip tubes randomly without observing	Flip both tubes and observe
Flowing Glass	Flip one tube only or flip tubes randomly without observing	Flip both tubes and observe

Amorphous Metals Cluster

Exhibit	Misuse	Intended Use
Can you Find the Supermetal?	Shuffle metals into slots, but do not figure out how to activate ball bearings	Empty slots; slide in all slots; push start and watch ball bearings (you will know they have done it correctly is you see the ball bearings bouncing)

Foam Cluster

Exhibit	Misuse	Intended Use
Feel the Foam	Throw foam samples; pick up only one foam sample; build with foam	Pick up and examine at least two different foam samples.

Crystals Cluster

Exhibit	Misuse	Intended Use
Tour a Miniature Crystal Garden	Just look but do not slide; do not look closely through magnifier	Look through viewer with eye close to magnifier at more than one crystal

Zoom Cluster

Exhibit	Misuse	Intended Use
View these Materials 16 times	Look through magnifier but do not slide microscope	Slide microscope and magnifier over objects and look through viewfinder
View the Materials 200 times	Look through at monitor but do not slide microscope	Slide microscope over objects and look at monitor
Feel the Force	Do activity but look at hologram to see result	Drag handle slowly across board

APPENDIX D
***Strange Matter* Interview Guide**
Removed for Proprietary Reasons

APPENDIX E
***Strange Matter* Web Site Interviews**
Removed from Proprietary Reasons

APPENDIX G
Relative Time Rankings of Remaining Exhibits

Table 27
Exhibits at which Visitors Spent Between 30 and 50 Seconds

Exhibit	*n*	Median Time
Identity panel/object/push button	31	50.0
Use the Magnet to Move the Fluid interactive (tabletop)	35	48.0
Crystals and You panel	2	46.0
View the Materials 16 times interactive	25	41.0
Which Materials Have Magnetic Personalities? interactive	50	39.5
Can you Find a Smooth Ride? Interactive	39	39.0
Tower of Bubbles panel (2)/phenomenon/staff	3	37.0
Material Girl video (4)	16	37.0
Materials Scientists Zoom In . . . video (5)	1	36.5
For Ferrofluids Size Matters! panel	1	36.0
Feel the Force interactive	17	35.0
Light Table interactive	36	33.5
Tempered Glass video (3)	21	33.0
For Tiny Particles Size is Big panel (2)	2	32.5
What's This Exhibition About? panel (2)	3	31.0
Zoom in 1000 times flip panel	7	31.0

Table 28
Exhibits at which Visitors Spent Between 29 and 14 Seconds

Exhibit	*n*	Median Time
Website computer interactive	13	29.0
Feel the Foams interactive	24	26.0
What's Cool about Crystals? Panel	2	26.0
Silicon Ingot and Wafers object/touchable object/magnifier	30	25.5
Aerogel panel/object	16	25.0
Aerogel pull-up-graphic	1	25.0
Tour a Miniature Crystal Garden interactive (2)	33	25.0
What's Making Those Strange Spikes? Panel	4	24.0
Foam in the Home panel	3	24.0
Crystals video	13	24.0
Shedding Light on Materials panel	1	24.0
Weird Waterfalls interactive	45	24.0
Clothing panel/object/touchable object	33	24.0
Tempered Glass and You panel	4	23.0
Zoom in 10x's Closer – Opal magnifier	5	23.0
What is this Amazing Morphing Metal? panel (2)	3	22.0
Tools panel/object/touchable object	15	22.0
Iceman video (4)	15	22.0
A Case of Comparing Crystals – Salt panel/object	1	21.0
Zoom in 10,000x's flip panel	11	21.0
Radiant Light Film touchable object	2	20.5
History: 1900s Microscope object	1	20.0
Been There, Seed That interactive	40	19.5
The Harder the Surface panel	1	19.0
Bread flip panel	15	19.0
Looks Can Be Deceiving panel	1	19.0
Down, Up, and Atom panel/object	1	19.0
Flowing Glass interactive	47	17.0
Open a Window interactive	26	16.5
Defects video (4)	11	16.0
A World of Magnets panel	1	16.0
Material Girl panel/object	5	15.0
Nitinol and You panel/object	18	14.0

Table 29
Exhibits at which Visitors Spent Between 29 and 10 Seconds

Exhibit	*n*	Median Time
What Do the Two Different Sizes of Ball Bearings Represent? Panel	2	14.0
Why do the Flowers Revive? Panel	3	13.0
Slip Sliding Away panel	1	13.0
History: Wood Under Microscope object	5	13.0
Opal 100,000x's pull-up-graphic	5	13.0
Cork flip panel	16	12.5
Tower of Bubbles panel (2)/phenomenon	6	12.5
This Shiny Column… panel	3	12.0
Amorphous Metals pull-up-graphic	5	11.0
Bone flip panel	13	11.0
Can You Spot the Defect? object	17	11.0
Can Metal Be Crystal? touchable object	7	11.0
How Do You Make the World's Hardest Metal? panel	3	10.0
Cushion flip panel	11	10.0
What do the Ball Bearings Represent? Panel	51	10.0
A Case of Comparing Crystals – Carbon panel/object	4	10.0
Teflon Crystal pull-up-graphic	3	10.0
Opal 10x's pull-up-graphic	1	10.0
Zoom Into the World of MEMS video	11	10.0

APPENDIX H
Relative Visitation Rankings of Remaining Exhibits

Table 30
Exhibits at which between 23 and 10 percent of Visitors Stopped

Exhibit	% Stopped
Please Walk on the Flowers interactive	22.6
Open a Window interactive	22.6
View the Materials 200 times interactive	22.6
View the Materials 16 times interactive	21.7
Feel the Foams interactive	20.9
Tempered Glass video (3)	18.3
What's Growing Here? Phenomenon	17.4
Theater – demonstration	15.7
Nitinol and You panel/object	15.7
Explore Opal's Essence magnifier	15.7
Can You Spot the Defect? object	14.8
Feel the Force interactive	14.8
Cork flip panel	13.9
Aluminum flip panel	13.9
Aerogel panel/object	13.9
Going with the Grain magnifier	13.9
Material Girl video (4)	13.9
Bread flip panel	13.0
Tools panel/object/touchable object	13.0
Iceman video (4)	13.0
Website computer interactive	11.3
Bone flip panel	11.3
Crystals video	11.3
Zoom Into the World of MEMS video	10.4
Materials Scientists Zoom In . . . video (5)	10.4
Cushion flip panel	9.6
Defects video (4)	9.6
Zoom in 10,000x's flip panel	9.6

Table 31
Exhibits at which between 9 and 2 Percent of Visitors Stopped

Exhibit	% Stopped
Aerogel flip panel	8.7
Sea Sponge flip panel	8.7
Iceman panel/object	8.7
Stem flip panel	7.8
Can Metal Be Crystal? touchable object	6.1
Zoom in 1000 times flip panel	6.1
Amorphous Metal and You panel/object	5.2
Tower of Bubbles panel (2)/phenomenon	5.2
Ordinary or Tempered Glass? panel/object	4.3
Amorphous Metals pull-up-graphic	4.3
What do the Ball Bearings Represent? panel	4.3
Zoom in 10x's Closer – Opal magnifier	4.3
History: Wood Under Microscope object	4.3
Opal 100,000x's pull-up-graphic	4.3
Material Girl panel/object	4.3
Tempered Glass and You panel	3.5
What's Making Those Strange Spikes? panel	3.5
Chipping Away at Silicon panel/object	3.5
What is 10x's Harder than Steel panel	3.5
Foam in the Home panel	3.5
A Case of Comparing Crystals – Carbon panel/object	3.5
History: 1600s Microscope object	3.5
What's This Exhibition About? panel (2)	2.6
Why do the Flowers Revive? panel	2.6
Nitinol's A Shifty Character panel	2.6
What is this Amazing Morphing Metal? panel (2)	2.6
This Shiny Column… panel	2.6
How Do You Make the World's Hardest Metal? panel	2.6
Tower of Bubbles panel (2)/phenomenon/staff	2.6
Much Ado about (Almost) Nothing panel	2.6
This Baby is Big? panel	2.6
Teflon Crystal pull-up-graphic	2.6
Xactly What is Happening with This Xylophone? panel	2.6
Radiant Light Film touchable object	1.7
For Tiny Particles Size is Big panel (2)	1.7
MR Fluids and You panel	1.7
What Do the Two Different Sizes of Ball Bearings Represent? panel	1.7
Crystals and You panel	1.7
What's Cool about Crystals? panel	1.7
Shedding Light on Materials panel	1.7

APPENDIX I
Social Interactions at Each Interactive

Table 32
Social Interactions at Each Interactive

Interactive	Number of Visitors that Stopped	% Used Exhibit with Others
Want to Feel Something Really Weird? interactive	29	76.6
Can you Find the Supermetal? interactive	38	65.8
Xylophones interactive	40	65.0
It's a Scope on a Rope interactive	41	63.4
Which Materials Have Magnetic Personalities? interactive	50	62.0
View the Materials 200 times interactive	26	61.5
Light Table interactive	36	61.1
Please Walk on the Flowers interactive	26	57.1
Use the Magnet to Move the Fluid interactive (tabletop)	35	57.1
Can You Hot Wire a Hole in One? interactive	29	51.7
Manipulate this Liquid (Ferrofluids) interactive	38	51.3
Feel the Foams interactive	24	50.0
Weird Waterfalls interactive	45	48.9
Smash the Glass interactive	75	48.7
How's It Shaking? interactive	33	48.5
Feel the Force interactive	17	47.1
Been There, Seed That interactive	40	45.0
View the Materials 16 times interactive	25	44.0
Tour a Miniature Crystal Garden interactive (2)	33	42.4
Flowing Glass interactive	47	34.0
Open a Window interactive	26	30.8
Can you Find a Smooth Ride? interactive	39	0.0

APPENDIX J
Misuse at Each Interactive

Table 33
Misuse at Each Interactive

Interactive	Number of Visitors that Stopped	% Misused Exhibit
Open a Window interactive	26	57.7
Can you Find the Supermetal? interactive	38	31.6
Feel the Foams interactive	24	25.0
Flowing Glass interactive	47	23.4
Light Table interactive	36	16.7
Can you Find a Smooth Ride? interactive	39	15.4
Been There, Seed That interactive	40	12.5
It's a Scope on a Rope interactive	41	12.2
Manipulate this Liquid (Ferrofluids) interactive	38	10.5
Can You Hot Wire a Hole in One? interactive	29	10.3
Weird Waterfalls interactive	45	8.9
View the Materials 16 times interactive	25	8.0
Please Walk on the Flowers interactive	26	7.7
How's It Shaking? interactive	33	6.1
Tour a Miniature Crystal Garden interactive (2)	33	6.1
Feel the Force interactive	17	5.9
Smash the Glass interactive	75	5.3
Use the Magnet to Move the Fluid interactive (tabletop)	35	2.9
Xylophones interactive	40	2.5
Which Materials Have Magnetic Personalities? interactive	50	2.0
Want to Feel Something Really Weird? interactive	29	0.0
View the Materials 200 times interactive	26	0.0

APPENDIX K
Specific Videos Watched to Completion

Table 34
Specific Videos Watched to Completion

Video	Number of Visitors that Stopped	Number that Watched Entire Video(s)
Theater – introduction video	1	1
Tempered Glass video (3)	21	10
Defects video (4)	11	5
Crystals video	13	1
Zoom Into the World of MEMS video	11	0
Materials Scientists Zoom In . . . video (5)	12	3
Iceman video (4)	15	1
Material Girl video (4)	16	6

APPENDIX L
Anonymous Written Responses of Peer Reviewers (unedited, as submitted to RK&A)

REVIEWER #1

I visited the Strange Matter exhibition at the Liberty Science Center on Friday, March 26, 2004 as part of a Peer Review panel convened by the Materials Research Society-originators of the exhibition-and Randi Korn & Associates, exhibition evaluators. The following is a summary of my experiences in the exhibition, and reflects ideas and opinions that I expressed during the course of the one-day panel.

I was looking forward to attending the exhibition because I am interested in the topic of materials science and I was eager to learn more about the notion of "stuff"-the variety of materials in our world, why and how they are made, how they are used, and the impacts of their design, fabrication, and use on our environment and society.

At the core of the experience, I found some intelligent and compelling ideas, but they were embedded in an overbearing and gratuitous design framework that obscured the information and dampened my experience. In retrospect, the elements that continue to be memorable for me are the ones that were simple, direct, and that featured and highlighted the actual materials. These include looking at materials under magnification, looking at a large sample of Aerogel, and using a magnet with the ferrofluids. I left the exhibition disappointed because I did not have enough direct interaction-even visually-with real materials.

Because the experience of an exhibition is so dependent upon its design, what follows is a critique of the exhibition design. Upon approaching the exhibition, which was laid out in an open space within the Liberty Science Center's lower exhibit floor, I had difficulty determining where to begin. All graphic elements of the exhibition were of similar scale and emphasis, with dense use of text and graphic symbols (such as the mysterious use of a multi-colored hand), all without visual hierarchy. I would have passed by the introduction if our hosts had not pointed it out to me as the place to begin.

The exhibition was full of school children on my first pass through it, and everyone was in a heightened state of activity: there was much button-pushing, crank-turning, xylophone clanging. But the experience seemed more like a playground environment, with kids darting from one physical activity to the next, rarely stopping more than a few seconds. Within that environment, it was difficult for me to concentrate on reading the large amounts of texts and deciphering the curious graphic symbols that were not immediately comprehensible. I interpreted the overall message of the exhibition as: The three-dimensional and graphic design of this exhibition is its most important aspect-much more important that the materials themselves. In fact, the design so overpowered the content that I had to work very hard to have a real experience with an interesting material.

Much of the interactivity seemed gratuitous-as if the developers used some sort of "interactive template" into which they could drop any content. In this case, it was about "materials." But it could just as easily have been about the circus, or patterns, or "Science 101." I wanted to see and

feel and use more types of materials. I wanted to compare and contrast materials. I wanted the exhibition to make use of a variety of interesting new materials in its design and construction. I wanted to find out about new materials currently under development.

The adjacencies and interrelationships of the various elements were poorly thought out. What do children with no hands have to do with clothing? What does money have to do with identity? What is Nitinol-a metal or a plastic? What "other seven foam samples?" What graphics go with what objects?

I left the exhibition feeling quite unsatisfied and a bit irritated. It seems that the "cleverness" of the developers was the real topic of the exhibition, not materials science. And I was disappointed. The whole domain of physical matter and materials design is so rich with display and tactile and conceptual opportunities. The exhibition could have been a very interesting, compelling, and memorable experience.

REVIEWER #2

1. My Personal Experience of *Strange Matter*

My initial feeling was of a touch of disorientation; where does the exhibit begin and what area does it encompass? The latter was, in greater measure, due to the "L" shaped footprint that wrapped around the escalators provided at LSC. However, locating the introductory panel was made more difficult than necessary by it being the identical size of the majority of panels in the rest of the exhibition (a concession to standardized shipping crates—but I would suggest either making one larger intro panel that would fit into the crate of another component or perhaps creating a larger panel from 3 of the standard sized panels). Also, the text did not seem to be large enough to command the hierarchical level of attention it deserved. The show title and perhaps a main intro statement should be legible from a further distance out. While *Strange Matter,* like most sci-tech center exhibitions, is obliviously not meant to be experienced linearly, studies have shown the importance and efficacy of providing visitors with advance organizers that will assist them in assembling their experiences into a conceptual framework. By the intro panel being equivocally sized, the opportunity to present the shows concepts was substantially diminished. As an analogy, the intro panel is the Sun; the various components the planets—visitors can, and many certainly will, bypass the Intro but it should be a visible organizing presence that can shed light on the exhibitions organization when desired.

As I made my way through the exhibition, it was apparent that many interesting, and attractive components were getting a lot of attention from visitors. On the most visceral level, this exhibition delivers "cool stuff" to play with. It has some new interactives that engaged me (particularly the magnetic fluids), as a jaded professional, much more than some of the old-style recycled Exploratorium Cookbook components commonly found at many sci-tech centers.

The video theater area was not being used by visitors during my visit. It had an uncomfortably high noise level (an unfortunate hallmark of budget value engineering that removed acoustical material from LSC's concrete ceilings) that made understanding the narrators almost impossible

(captioning was optional?)—but sci-tech centers are, almost by definition, noisy—so this problem will most likely be present at subsequent venues. I would suggest partially enclosing the theater by affixing acoustical panels to its frame. Also, this could create a large outer face that could be found suitable for displaying the show title in large letters (as opposed to one of the far walls). Furthermore, the intro panel could be situated adjacent to the theater and thereby perhaps achieve a critical mass and create a focus to help get visitors orientated.

I found most of the exhibition graphics lacked the sort of hierarchical layering usually accomplished through text formatting. Overall, the various topics on the large labels were not layered into visual chunks in a way that would facilitate use by visitors in the "bolter" or "browser" categories—everything seemed to be set to, as in a magazine article, use by a "burrower". A caregiver asked a question by a young visitor is presented with little in the way of being able to quickly find a response regarding a particular material or the process illustrated. Many times, at various institutions, I have seen a caregiver in a similar situation look briefly around, and when confronted with a long unlayered label, make up an answer—this reply often totally misses the point.

As I toured the exhibition I might happen to approach one of the thematic "pods" from a non-primary side and there would not be a clear title that linked all sides of the pod as parts of one greater thematic cluster.

Occasionally, the illustrations on the panels, while labeled with all the necessary parts, also seemed to lack a hierarchy of text size. For instance the three equal-sized illustrations depicting various wires had the name of each material (what visitors needed first to set context) set to same size as the rest of notations. I also find it helpful if illustrations can convey information visually as well as through text—for example an illustration of a cross-section of glass being pressed on could be shown, instead of as a blue line being warped by a force arrow, as three dimension rendering of a recognizable section of window pane, partially framed, with a hand, labeled force, pressing down.

Sometimes I was puzzled as to why certain illustrations did not help make the invisible visible. For example, the illustrations I saw regarding the alignment of molecules of magnetic fluids showed that when a magnet was present the molecules would align into a pattern. What I thought might help would be to show some blue(?) lines arching between the magnet's poles and passing through the material and that this is why the molecules are essentially strung into a beadlike pattern. Also in a similar vein, (and perhaps I missed it) I wish we had another half an hour to tour the exhibition) I didn't see anything that directly illustrated why the magnetic fluid developed their beautiful, almost entrancing spikes.

At interactives like the one displaying the Nitinol wires titles like "Don't Step on the Flowers" may be cute, but I believe they forgo the opportunity to provide a hook that also has embedded context (as an insufficiently honed on-the-fly suggestion: "Wire that Remembers"). There's nothing to say that this--literalism to assist visitors--can't coexist with a sense of whimsy (the boot lowering device could be labeled something like "the Stompinator"). I thought it might be helpful to segment the Nitinol garden patch into labeled plots (mirroring the structure of the

comparisons presented in the labels) containing Nitinol and copper wire. Of course the copper would never be restored after the first stomp, and the Nitinol would miraculously respond to heat

Visitors were most definitely attracted to many of the interactives. They seemed well maintained and robustly designed. I thought there were a couple of impediments preventing visitors, particularly those without some pre-existing knowledge base, from moving from "getting interested" to "getting it" or making the connections. The critical title or sentence, or two, that would allow visitors to contextualize an interactive was frequently on a, rather monolithically, formatted label placed three or four feet off to one side. I would like to see these critical bits, where possible, put as close to the "point of purchase" as possible. Many users will bypass the labels and go right to the hands-on. The right words for this specific task can be quite difficult to tease out (I believe among the most difficult tasks facing an exhibition team)—since this is where the rubber meets the road (it has to have a hook, yet be accurate and relevant to the physical interactions and the results shown . . .) but through judicious use they can, far from interfere, instead enrich the net experience of the visitor.

Similarly I saw, and experienced, some difficulties created by a lack of direct labeling regarding the manipulative components of some of the interactives. A visitor who may have no knowledge in this area and who may be engaged in a conversation, or in fielding questions from others in their group, will have reduced bandwidth available to operate the interactive and then make connections between cause and effect. Anything to make the basics of those causes and effects transparent will be beneficial (during the planning process it naturally becomes increasingly difficult for the team members to project themselves back to the disconnected un-cued in state of the visitor who walks in cold). For instance, the quite cool Magneto-rheological fluid interactive (which unfortunately became an out-of-context glass cleaning exercise for some—maybe a shelf projecting above the back of the hands in the glove box could prevent some splashing the inside of the glass) had an essentially unlabeled button that moved the magnet in or out. I thought to help visitors make the connection, it would have been interesting if the magnet could be clearly seen as it moved and the button ("Move the Magnet"?) or component labeled something with a title cueing visitors to look for the material's change in firmness due to magnetism (e.g.-"Feel the Difference a Magnet can Make"?). Also some interactive components, like the lower magnet of the Ferrofluid, were situated hidden underneath and there was no arrow or illustration or second lever letting visitors know that there was something to interact with below and that it was critical in successfully seeing the intended phenomena (I would guess about 1/3 or more of the visitors—if they hadn't seen someone using the lower magnet--didn't even know that it was there).

The shattering glass video added a nice view of what will happen concerning the glass panel vs. bowling ball interactive. It would be nice if the various programs, selected by a button push, were given simple screen captions so other viewers watching would know it was un-tempered glass slowed to $1/10^{th}$ normal speed, etc.

The tunnel displaying various materials from the Iceman to today was a good way to bring in some interesting artifacts. It also, since it was a little less active and noisy, seemed like a good place for caregivers, or older visitors, to browse in.

Overall, I thought the exhibition was worthwhile and I personally had fun experiencing many of the interactives. The areas I thought most problematic were that the links between interactive and information (whether text or illustrations) were not placed in ways that would optimally facilitate easy connections and that the text panels were monolithic and hierarchally equivocal in voice—this left visitors without an easy way to quickly locate the chunks of information that they might be interested in. Perhaps formatting the different flavors of information in different ways might help (e.g. show "Everyday Magnetic Fluids" using primarily images of examples from daily life--like a hard drive with a callout arrow, or line of text if needed, showing the point of interest as opposed to another block of text).

2. Ratings for *Strange Matter* referenced to *Criteria for Assessing Excellence in Exhibitions from a Visitor-Experience Perspective*

I initially, in the limited time we had in the busy gallery, found it a bit difficult to process the adaptation of Serrell and Associates form. I found that some of the aspect categories were easily evaluated and could be reduced to a simple notation while some others were a bit broad in scope--to the point where I felt multiple areas or variables were involved (some I may have given a "+" while others in same category I saw as a "-") and that these were much more based on personal interpretation. Furthermore, I had some quandary when presented with an array of notations that included no average value ("A good example" or "Not quite there" were the closest). As a tool to focus thought or conversation I thought the form was useful and, if you wish, I can forward you a copy with my specific numbers and notations. I personally feel that fine processing of the numbers will be a bit reductivist and that this process seems be best suited to getting a general consensus as to where an exhibition falls on a spectrum and that it wouldn't be of great utility in generating responses out to the decimal point.

3. *Strange Matter* in relation to other exhibitions in the field

I believe that *Strange Matter* falls somewhere in the middle of the success spectrum. It is a competently designed project that brings specialists' knowledge and materials out to the public and is laudable in it collaborative goals. Inventing new interactives that are essentially easy to understand, repeatable experiments that also need to be vandal resistant is quite a formidable challenge.

It doesn't illuminate any superscalar or ethical questions in a way that will affect a visitor's worldview—but that's ok, it's about the pleasure of getting your hands dirty in exotic stuff. I am sure that it will be quite successful as it tours. It has a good titling and the subject is viscerally easy to get a handle on.

I don't think that *Strange Matter* is assisting visitors in making connections as much as it could and that the graphic panels are, largely, (in layering, placement and illustrations) below the current standard set by recent similar exhibitions.

I believe that with a bit of remedial refitting (making the intro area have more presence, cross-linking the various sides of the topic pods and connecting the interactives and directions more directly) *Strange Matter* could pull it's educational aspirations closer together and align with visitor needs and behavior to create a more solid and substantial project.

REVIEWER #3

Experience in the exhibition

Arriving at the bottom of the escalator it was difficult to ascertain where the exhibition began. Typical of many science center exhibitions I saw many pod-like structures made of a heavy looking metal and assumed these structures focused on different content—with this assumption, I began exploring the exhibition. At the far right section of the exhibition I could not help to notice a large and impressive demonstration stage. All the design cues told me this was an important part of the experience and I should make an effort to attend a demo. After searching for the introductory label I read it but left without a clear sense of the exhibit's main message or an organization overview to "hang on to." The label was difficult to find because the exhibit structure itself did not call attention to it and the label hierarchy did not indicate it was more important that the rest of the exhibit text. I am not a diligent label reader but I always read introductory labels if I can find them—I personally need the conceptual structure to organize and assimilate my experiences. I believe in the old saying: "Tell then what you are going to tell them, tell them, and then tell them what you told them."

The exhibition was busy with school groups which is typical on a weekday during the school year and I often had to wait my turn to use an interactive. This gave me a chance to see how others were using and reacting. Just like many visitors I approach an area, go directly to the interactive and if that experience was satisfying I devoted some of my time to reading supplemental information.

In terms of circulation I ended up skirting around the edges of the exhibit trying to avoid large masses of kids in the middle and unfortunately missed the foam and smash the glass components on the first pass through the exhibit. In the first 40 minutes of our initial time in the exhibition I experienced some portion of about 50% of the show. Later in the day we had more time to return to the exhibition and I eventually experienced every element.

Critique

If the goal of the exhibition was to introduce visitors to material science as a science and provide some direct hands on experience with a few new and novel materials then the exhibition succeeded. If however the goals were more ambitious and sophisticated than this, as I suspect they were, then there were many missed opportunities. I later learned from the website that the exhibition investigated "four critical areas of materials science --- structure, properties, processing and performance." As I was experiencing this exhibition, I some cool experiences, some confusing ones but I had no idea that there were these other big intended messages.

What worked: Clearly the area of materials science is a rich and exhibit-able topic for science museums—I hope this is just the beginning of our profession's exploration of this area of science. The developers did a good job of selecting or including only those materials that

produced good and inherently interesting interactives. There were a few exceptions to this (ball bearings and xylophones were not successful). I appreciate immense amount of time and effort it takes to produce good, solid, bullet proof interactives and I could see the difficulties in attempting to use some of these new materials in an exhibit setting.

Magnetic Liquids, Smash the glass, Foam, Materials Evolution and the Material Touch Table were the most satisfying experiences for me. In these components messages were fairly easy to grasp, I did some thing interesting and most importantly walked away thinking about the topic in a slightly new way.

The Demo stage appeared to be a crowd pleaser and allowed exploration of some materials and ideas that were not appropriate for a stand alone exhibition. This type of experience is not my personal favorite in any science museum regardless of the topic, but I think my kids would have enjoyed it.

What didn't work or could have been better: The design of the pod-like structures often overpowered the intended focus of the experience—drawing attention away from the featured interactive, material and/or graphics. The problem was both in chosen material used in construction (visually heavy and overpowering) and the design configuration (pod-like). It is challenging to design traveling exhibitions that can be installed in many locations and still retain storyline cohesion. However, requiring the visitor to walk around in circles to continue to explore a topic is not logical or acknowledges typical visitor circulation behavior. A much more effective organization would have been to design a structure that allowed for a seamless investigation of the topic regardless of its medium (interactive, beside text, next to video, etc). Since I was critiquing the exhibition I made an effort to investigate all sides of the pods—I don't believe visitors are this diligent and all the effort to develop the accompanying text and graphics were lost to those not willing to walk around in circles. Exceptions to this comment were the Foam area, Smash the Glass and Materials Evolution—where the design and configuration aided me in experiencing the section as intended. The design of the foam area in particular helped me gain the intended message of comparing and allowed the foam in the center to be the star of the show. In one instance the pod structure actually obscured the intended content. The ingot was in the center of a pod structure and my eyes were drawn to it only after studying the text panels for quite a while. This was a beautiful object worthy of a very artful display. The concept of the ingot being born of the sand was interesting but I had to work to get very hard to get this message. The pod swallowed this very interesting object.

Perhaps the most disappointing aspect to the exhibition was the graphic design. The text hierarchy lacked the sophistication to help the visitor use the exhibit as intended and did not enhance the exhibition in anyway. There seemed to be a lack of understanding of typical reading behavior that allows for both readers and skimmers. Images when used in supplementary text panels were not large enough become visual hooks—huge missed opportunity. The over designed type treatment overpowered the content. Simple, elegant straightforward type design allows intended message to remain center stage.

Overall I had a good time, not a great time-- mostly because I had to work much harder than necessary to create a satisfying experience. (I was surprised that basic "to do" copy was not clearer—I seems basic formative evaluation of prototypes should led to better directional labels). Although the exhibition used new and novel materials, I'm not sure the exhibition broke any new ground in its presentation of this topic.

REVIEWER #4

My reactions to the exhibition

I found the exhibit interesting and very engaging.

- The subject matter was very interesting and provided an opportunity to cover many everyday aspects of science and technology in guests' lives.
- There was the opportunity to see scientific phenomena and technology that I had not seen or interacted with before.
- There was a very good mix of different experience media including interactives, multimedia, observation tools, real artifacts, graphics and demonstrations.
- A good demonstration space
- There was real stuff and real processes – the heart of a good science center exhibition.

I found the organization of the exhibition somewhat confusing.

- The organization of the content was not readily apparent from the design or the layout.
- I missed the entrance into the exhibition.
- In parts of the exhibition – "Tunnel of Text," "Silicon" and others – the main message of these exhibits was not clear.
- There seemed to be an overall theme of "scale" as shown with the slide out scale graphics, but this was not carried out well in a more thorough, obvious approach.
- The text in the "Tunnel of Text" needs better organization with this amount of information.

At times, the exhibits made it physically challenging to learn.

- The xylophone was way too loud and made for a very harsh environment.
- There were certain materials that were not labeled (i.e., Friction Slide), therefore not offering an opportunity to make connections with other exhibits.
- There were parts of the exhibit that were not clearly labeled or designed to suggest the actual operation – in particular, the Ferrofluids exhibits were guilty of this.
- At other times, the exhibits didn't allow for highlighting the artifact that was presented, such as the Silicon ingot.
- At times, the graphic design of the exhibit made it very difficult to learn. There was too much text in the tunnel, and there were times when there were panel or artifact shadows directly on the text, or you were asked to read text through an artifact case.
- Some elements of the exhibit design tended to promote "just pushing a button," while there were others that were more open ended.

The experience in the exhibit was very different depending the audience present.

- The morning was almost unbearable with the sounds from the exhibit matched with sound of the children.
- In the afternoon there were fewer audience members, which improved the visit and the learning.

The design and content could have made some better choices in materials (no pun intended).

- Knowing that there would large numbers of active children in the space, there could have been more thought on acoustics.
- Using different materials for the structure of the exhibit might have been interesting.
- There was little diversity in the scientists who were represented.
- Some of the video shown had people not looking at the camera, which is annoying, when the goal is to have them talk to the guest.

My ratings on the Serrell Scale

Comfortable:
5 – A balance has not been achieved, meaning a 4 was not possible. Overall, the issues with design, acoustics and frustration one might face from poor organization makes it a missed opportunity.

Engaging:
3 – I found this a very engaging exhibit. There was some missed opportunity in labeling materials and in materials used, but a really good balance of activities and media.

Reinforcing:
4 – Although I did find some themes reinforced throughout the exhibition, I also felt that themes, such as scale and others, did not come through.

Meaningful:
4 – While I do think that the exhibit offers some possibility of people being more aware of materials, I do not think there was anything "transformative" about the experience. Missing from the exhibition were any issues about materials.

Lessons for the field

The following are some comments concerning exhibition development and design that the field should know:

- There are distinct operational audiences that all exhibition and design should take into account – school groups and families. Perhaps most simply, school groups tend to be louder, less focused on the learning and are under little supervision. Helping this group focus ("involving" interactives – not push buttons, improved acoustics, etc.) will help families.

- Real stuff and real processes are powerful. This exhibit is a prime example of how true this is. Although I was uncomfortable and at times unhappy, the real stuff and action made me have a good time.

- I believe that audiences, especially older ones, are more and more sophisticated in evaluating what they are learning about. The lack of any issues that concern materials, from recycling to the environmental impacts of raw materials used for these substances, was obvious. I think that we as a society must concern ourselves with these questions, and that science centers must play a role in giving people information so that they can make informed decisions.

REVIEWER #5

My reactions to the exhibition

I had difficulty in organizing my experience.

- The entrance to the exhibition was difficult to find, as was the main label.
- As I looked out over the entire exhibition, I saw no themes or patterns.
- The overall noise and clamor in the exhibition made it difficult for me to get into the content.
- Walking around the 3-sided structures was confusing; I often came upon less important information before I came to the main idea, and then had to move around the structure to get to the overall point.
- The little slide-out scale was a nice touch for consistency but I often could not understand how the scale was related to the particular component – too much text, too small, relationship not highlighted enough.
- I completely missed the point that the Zoom section was about scale. There was too much text. Something visual like smaller structures at the smaller end of the scale and larger ones at the end might have given a visual clue as to the overall message.
- I did get the idea that materials have specific structures and properties, and that these are important to study and understand. The areas where one can examine structure of materials under magnifying glass were very engaging.
- I did not get the idea that there are people who study materials and create new materials. Materials scientists and their stories could have been highlighted more.

The design created the impression of a hard, cold, industrial environment.

- The materials seemed mostly to be walled off by glass or other barriers.
- It would have been a wonderful enveloping experience to have made the exhibition itself out of a variety of materials (warm and inviting like wood and textiles as well as colder, harder materials) that visitors could touch and experience.

The exhibition (in the morning) was incredibly loud with hyperactive kids.

- The exhibit creates enough excitement without adding to the overall ambient sound with the xylophones. These could be eliminated without damaging the content at all.
- The push-button activation for videos and other activities just encourages kids to bang on the buttons. I observed this repeatedly, with kids not waiting to watch the videos.
- It seems that we know enough about activity in exhibitions to design experiences that work well both when an exhibition is crowded and when it is not. The afternoon experience when

the exhibition was almost empty was more satisfying for me. Mainly because the xylophones (and also the ball continually banging against the glass) did not distract me, I could concentrate on the exhibition. OSC designers are extremely experienced and I don't understand why, if they were creating noisy components, they did not include some kind of sound insulation.

There were many engaging activities. The exhibition confirmed once again the skill of OSC in taking science concepts and transforming them into 3-D experiences.

- The foam area was especially interesting to me. I liked activity of identifying different everyday materials through their magnified structure. I liked the idea of grouping bread, soap bubbles and sponges in the same category.
- I did not see many components where people could work together. They could be beside each other but not really work collaboratively on an activity.
- I did not see many components that were open ended; most activities, interesting as they were, asked you to explore to get a specific "correct" point or idea, which was also explained in the text.
- The demonstration area is a good feature, and the demonstration I saw was both entertaining and informative.

I found the graphics and textual information off-putting.

- Labels were written for kids, utilizing really bad puns and lots of exclamation points. With all the exclamation points, something that is truly amazing gets lost in the shuffle.
- Pretty much only the adults were reading, so the labels should be written in more adult language- this can still be quite simple and straightforward – just lose the puns.
- At the same time there was way more text than needed and it was often written in very small type- difficult for this glasses-wearer to read.

<u>My ratings on the Serrell Scale</u>

Comfortable:

I rate the exhibition a **5** because the design is inherently cold and industrial, and there is little seating. All of these physical features, in addition to the noise created by the xylophones, encourage hyperactivity in groups of children. The lack of clear organizational structure made the exhibition less than welcoming for me.

Engaging:

I initially gave the exhibition a **3** but in retrospect would give it a **4**. Many of the individual components were very engaging both to me, and to the visitors I observed. What they are taking away from their involvement with the activities, and whether much of it was just hyper-activity, is another question. Summative evaluation should tell whether the engagement translates into greater understanding of materials science.

Reinforcing:
I rate it a **3** – good with some misses. I did find that most components reinforced other components in terms of the emphasis on the structures and properties of materials – one of the main messages of the exhibition. But other messages- such as that there are people called materials scientists- did not come across strongly initially to me, so were less capable of being reinforced.

Meaningful:
I rate the exhibition a **3-4**. I did learn something about materials science from the exhibition, but I could not say it was a "transformative" experience.

Lessons for the field

The experience of viewing the exhibition twice, as well as participating in the discussion on March 26, leaves me with a sense that a number of opportunities were lost in creating an exhibition that is forward-looking for the museum field

- The issue of sound (e.g. overall sound, bleed from AV, etc) in exhibitions is one that is being discussed more and more in the field. It is incomprehensible to me that this exhibition was designed with so many inherently noisy components with no effort to reduce the overall impact of sound. This would have been a chance to experiment with new ways of dealing with sound – perhaps even using some of the knowledge gained by materials research !- or at least to use a traditional method such as a sound booth.

- The child-centered orientation of science centers, their declining visitation, and the aging of the general population are also topics that have been discussed in recent years. There has been much more emphasis on creating exhibitions that are multi-generational in appeal, with efforts to attract adult audiences. This exhibition topic is one that could be interesting to many age levels, but the general design and the language of the text communicates that this is an exhibition primarily for kids. This is a missed opportunity for science museums to attract an adult audience.

- There was some attention given in the exhibition to questions of environmental impact- although I missed it – I was told it was there. But generally, the exhibition is an example of the traditional science center presentation of science as, at worst, neutral, and at best, contributing inevitably to the march of progress. In particular if we are going to create exhibitions that appeal to adults, we need to place science and technology in a broader context and present it with a more questioning attitude.

- It seems that a number of lessons that might have been learned in previous collaborations between a museum and a professional association (e.g. *Science in American Life* and *Psychology*) were not applied here. These collaborations are inherently contentious because of the very different organizational cultures of the two partners. But strategies can be developed to bridge these differences constructively. And, in the last analysis, the professional association is the client and the museum is the contractor. My impression from our meeting was that in many cases the issues raised in the above critique were raised by MRS but that OSC was not responsive in the way that a contractor should be. In my view it

is important that the senior management of MRS communicate with the senior management of OSC regarding this issue of non-responsiveness, for two reasons. First, MRS is going to have to work with OSC on the remediation of the exhibition. Secondly, outside entities are not going to want to work with OSC International Marketing if they gain a reputation for a non client-centered approach.