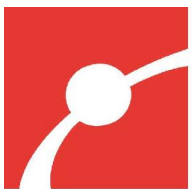


Listening to Visitors: What's Broken at the Museum of Science? **Exhibit Maintenance Evaluation**

Report Written by Elizabeth Kunz and Christine Reich
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National Center for Technological Literacy

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EXECUTIVE SUMMARY

In 2005, the Exhibit Operations Department at the Museum of Science, Boston became concerned by the number of visitor comment cards that cited frustration with broken exhibits. As a result, they approached the Research Department to carry out a study to determine the visitors' perspectives of maintenance issues. The Research Department addressed this matter by seeking answers to the following questions:

1. Where is the discrepancy between what visitors and maintenance workers call broken?
2. What factors related to broken exhibits frustrate visitors most?
3. What counts as broken in the eyes of the visitor?

Data were collected between August and December 2005 in five galleries within the Museum: *Seeing the Unseen*, *Investigate!*, *Messages*, *Natural Mysteries*, and *Making Models*. These galleries were chosen because collectively they represent older and newer galleries, and a range of exhibit types including hands-on, computer-based, and object-based experiences. A variety of methods were used to collect visitor data including comment card reports, exit interviews, visitor surveys, timing and tracking maps, and maintenance surveys. The use of multiple methods enabled us to look at this issue from many perspectives and capture the breadth and depth of visitor concerns about broken exhibits.

The data show that there is a discrepancy between visitors and maintenance workers in both the number and types of exhibits they call broken. In addition, visitors had more frustration in older galleries, and much of this frustration had to do with computer-based exhibits. Finally, visitors almost always identified non-functioning exhibits as broken. They were less likely to call partially functional exhibits broken, and they never called exhibits with cosmetic problems broken.

It is recommended that the Maintenance Department revamp their exhibit maintenance reporting system so that all workers know what the Department considers broken, and so that they report these problems in the same way. In addition, the Exhibits Department should continue to complete usability tests with increased emphasis on the quality assurance of computer-based exhibits. They should also design exhibits in such a way that chronically broken exhibits can be moved off the Museum floors and should update exhibit labels to reflect changes as exhibits are altered.

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INTRODUCTION

A common complaint of visitors who attend museums with interactive exhibits is that too much is broken. In 2005, on the Museum of Science, Boston customer comment cards, these complaints were second only to visitor service issues. In an effort to try to decrease negative comments and increase the enjoyment of visitors, Dan MacDonald, Manager of Exhibit Hall Operations and Technology Resources, and Brian Worobey, Vice President of Information Systems & Resources, asked the Research Department to complete a study that would explore how the issue of broken exhibits at the Museum of Science can be improved. The purpose of this study was to try to determine how to improve visitors' perceptions of the number of broken exhibits in the Museum. In order to find out if this is possible, the following questions were explored:

1. Where is the discrepancy between what visitors and maintenance workers call broken? What accounts for the discrepancy between the percentage of exhibits perceived to be broken from the perspective of the visitor versus the percentage reported by the exhibit maintenance? Is there an internal discrepancy in the maintenance department? Are visitors stopping at broken exhibits more frequently than those that are operational? Do visitors perceive that a higher-than-actual number of the exhibits they visit are broken?
2. What factors related to broken exhibits frustrate visitors most? In what ways, if any, does visitor frustration increase when the most popular or iconic exhibitions are not in operation? How can we decrease this frustration and other frustrations with broken exhibits?
3. What counts as broken in the eyes of the visitor? What qualifies as operational versus non-operational from the perspective of the visitor, and how does that differ from the perspective of the technician? Do visitors count as "broken" those exhibits that they cannot operate, or do they only count those that are truly not in operation? Do visitors only count as "operational" those they perceive to be "interactive"?

These questions were explored by employing a mixed-method research study at the Museum of Science. Development of protocols and instruments took place from May through July 2005, and data collection occurred from August through December 2005. Data collection methods included exit interviews, timing and tracking data, visitor surveys, focus groups, maintenance surveys, and internal comment card reports from

2005. The data presented to the Exhibit Operations Department includes recommendations about how they can streamline the maintenance process by focusing on the problems that visitors are most aware of. At the same time, this report describes maintenance problems that are not as troublesome to visitors and also describes issues that need to be considered during exhibit development.

THEORIES ABOUT BROKEN EXHIBITS

Very few visitor research projects addressing exhibit maintenance have been published, and only a few unpublished studies regarding the issue have been found. The studies that were located focus on design of exhibits and the times when broken exhibits are most likely to be a problem for visitors.

Design of Exhibits

Two papers were found discussing reliability of computer exhibits and difficult to use exhibits. These papers show that visitor use of exhibits is an important part of how visitors view and feel about broken exhibits.

Jim Oker discusses the reliability and design of computer interactives. He explains that no matter how good the design or “reliable a system is, it may go down at some point” (Oker, 1992, p. 163). Therefore, it is important to consider the hardware that is used in a design. “Lots of moving parts can mean trouble (printers, video tape players, etc.); items that require care and feeding are tough for most museums to keep up with (e.g. printers that require ribbons, paper, and un-jamming); and industrial equipment is often more reliable than consumer equipment (but sometimes it’s just more expensive)” (Oker, 1992, p. 166). In addition, the computer software needs to be reliable because “a poor interface will be perceived as a broken program” (Oker, 1992, p. 167). These software problems include slow programs that may make the visitor think an exhibit is broken or may make a visitor act aggressively toward the exhibit, which then causes the visitor to break the exhibit. This paper demonstrates that computer interactives need to be carefully designed in order to produce positive results for visitors.

In 2001, Joshua Gutwill, from the Exploratorium in San Francisco, completed a study looking at visitor frustration with “challenging” exhibits. Gutwill defines a “challenging” exhibit as one that a visitor “tried to get to work, but could not” (2001, p. 2). Gutwill hoped to find out “(a) how frequently visitors experience Exploratorium exhibits as challenging (difficult to use), (b) whether a sign placed on challenging exhibits would be helpful to visitors, and (c) which sign text is most popular with visitors” (2001, p. 2). He found that 47% of 120 interviewed visitors encountered an exhibit, which they could not get to work (Gutwill, 2001, p. 3). It was explained that

“one difficulty with this type of data was that we did not know whether exhibits were actually challenging or were simply broken” (Gutwill, 2001, pp. 3-4). Looking into these exhibits further, it was found that 29% - 82% of these exhibits might have actually been broken (Gutwill, 2001, p. 4). This leads to the question of whether visitors might have called these exhibits broken if the interview questions had been asked differently. In fact, 10% of people in the study remark that they “thought [the] exhibit was broken” so they moved on when they encountered it (Gutwill, 2001, p. 6). If the exhibit was actually challenging, 85% of the people in the study said that they would find a sign telling them that a museum volunteer can aid them with the operation of the exhibit helpful (Gutwill, 2001, p. 9). This study shows that exhibit design can be a major hindrance to visitors trying to interact with an exhibit. It is a strong possibility that if a visitor encounters a “challenging” exhibit, they will believe it is broken.

When Are Broken Exhibits a Problem for Visitors?

One study has come the closest to looking at the issues that will be explored in this study: a summative evaluation conducted in 2000 by Randi Korn & Associates, Inc. for The Tech Museum of Innovation. Some information from this paper was presented by Susan Wageman at the 2001 American Association of Museums Annual Meeting in the poster session “Everything is Broken: Visitor Perceptions and Reality.”

The summative evaluation studied the four galleries at The Tech Museum of Innovation: Life Tech Gallery, Innovation Gallery, Exploration Gallery, and Communication Gallery. One of the staff’s concerns that was explored through this summative evaluation was “the number of broken exhibits encountered by visitors” (Randi Korn, 2000, p. 19). According to the report, “during the study, each gallery contained between one and eight broken exhibits” (Randi Korn, 2000, p. 21). As Randi Korn states, this is not a very high percentage of the total number of exhibits in the museum: however, “it is not the incidence rate of broken exhibits that is important, but rather the visitor perception of the number of broken exhibits in the gallery” (2000, p. 21). Overall, three-quarters of visitors reported encountering broken exhibits, and one-quarter “were disappointed because there were broken exhibits” (Randi Korn, 2000, p.

21). This shows that broken exhibits at The Tech Museum need to be a prime concern for the museum's staff.

Susan Wageman's thoughts emphasize this point. Since the report, The Tech Museum has made it a priority to keep the uptime of exhibits at "a target of 95%" (Wageman, 2001a). This target, she says, was influenced by talks with staff at the Museum of Science. The Tech Museum has also found that it is critical to keep 50 "high-impact exhibits" working at an even higher level. "It appears that uptime for the top 50 high-impact exhibits is a better indicator of potential visitor satisfaction or displeasure than uptime for all exhibits" (Wageman, 2001a). This seems to indicate that keeping the most popular exhibits in any gallery operational will also have a positive impact on visitors' perceptions of broken. In addition, Wageman believes that a busy museum can have a negative impact on the visitor perception of broken. She says:

Imagine... You are in a crowded museum and there are people using EVERY exhibit. No, wait! There's an empty station! You rush over – then notice the "out of order" sign. Hmm... Look over there! A couple is leaving that station!... No wonder, it's broken, too. How much of this would it take for you to think that "everything is broken?"

(Wageman, 2001b)

In order to camouflage broken exhibits, Wageman suggests removing signage and buttons that do not work, presenting programs in front of the exhibit that distract from it, turning the broken exhibit into a learning experience, offering extra programming, or training staff to direct visitors to other similar exhibits (Wageman, 2001b). To Wageman, the two most important parts of keeping visitors happy about broken exhibits is to keep the number of broken popular exhibits low and redirect visitor attention when the museum is busy.

This paper hopes to explore the validity of some of these theories through a focus on the visitors' perceptions of broken exhibits. The paper will look at whether downtime of popular exhibits is important, whether all "broken" exhibits have maintenance problems or if some are "challenging," and whether type of exhibit has an effect on whether or not it is reported as broken. With this information in hand, maintenance policy can be changed to improve the visitor experience.

METHODOLOGY

Data were collected at the Museum of Science, Boston starting in August and ending in December 2005. Methods employed included timing and tracking maps, exit interviews, visitor surveys, and focus groups. Additionally, maintenance logs and comment card reports were consulted to gather further information. Using multiple methods to collect this data allowed the researchers to examine the issue of broken exhibits from a variety of angles and thus capture a fuller picture of the visitor's experience with broken exhibits at the Museum of Science.

Selection of Study Galleries

The galleries that were used in this study represented both older and newer exhibitions, as well as hands-on activities, computer-based interactives, and static objects. The five galleries were: *The Observatory: Seeing the Unseen* (STU), *Making Models/Mapping the World Around Us* (MM), *Investigate!* (Inv), *Natural Mysteries* (NM), and *Messages* (Mess). Four of the five galleries included in this study are "Science is an Activity" centers. These galleries focus on engaging visitors in activities that promote science-thinking skills. While each gallery includes open-ended, hands-on activities, they vary in terms of the numbers and types of interactives included. The variety of galleries were chosen to determine if there is any difference in the broken exhibits that visitors find in widely variable exhibitions. A summary of the exhibitions can be seen below (Table 1).

Table 1. Age and Description of Galleries in the Study

Gallery	Opening Date	Is it an activity center?	Types of Exhibits
<i>The Observatory: Seeing the Unseen</i>	November 18, 1991	Yes	Computers/Activities
<i>Investigate!</i>	March 9, 1996	Yes	Computers/Activities
<i>Messages</i>	May 27, 1999	No	Computers/Activities
<i>Natural Mysteries</i>	May 23, 2000	Yes	Computers/Activities/Static Objects
<i>Making Models</i>	June 26, 2003	Yes	Computers/Activities/Static Objects

Selecting Study Participants

In total, 225 visitors, museum volunteers, and Fenway High School students took part in the study. Most of the participants were either timed and tracked as they visited *Making Models* and *Seeing the Unseen* or interviewed as they left the five study exhibitions. Other participants were invited to contribute by filling out a visitor survey and attending a focus group. The number of participants for each data collection instrument can be seen below (Table 2).

Table 2. The Number of Study Participants for Each Instrument

	<i>The Observatory: Seeing the Unseen</i>	<i>Investigate!</i>	<i>Messages</i>	<i>Natural Mysteries</i>	<i>Making Models</i>	Total
Timing and Tracking Maps	50	0	0	0	58	108
Exit Interviews	25	25	25	25	25	125
Visitor/Fenway Surveys	4	5	9	0	10	28
Volunteer Surveys	0	4	4	0	6	14
Maintenance Surveys	6	5	4	3	9	27

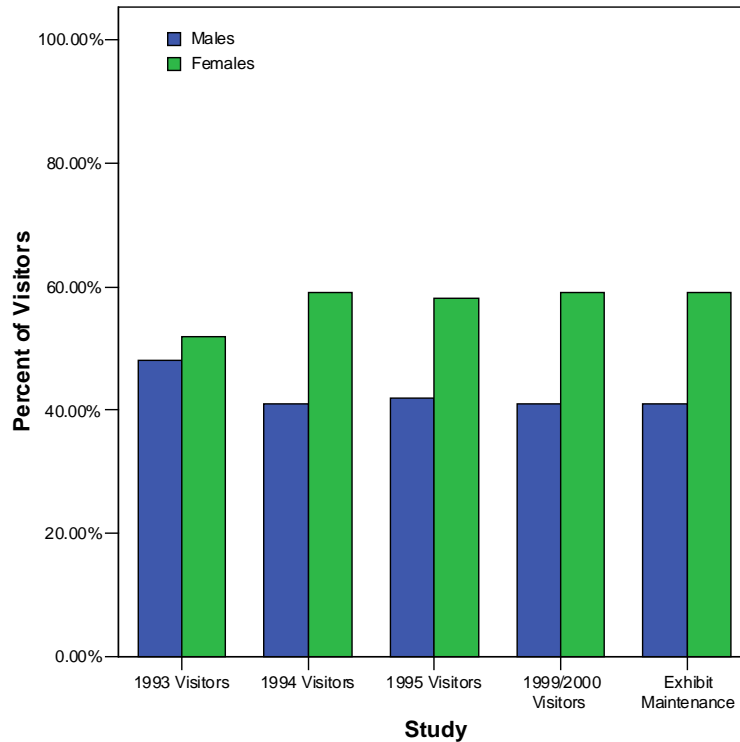
All participants were at least 10 years old, and most were 20 or older. This population was chosen because it was felt that they would be more concerned about broken exhibits than younger visitors, and because it is the adult visitor that primarily serves as the decision-maker regarding whether a family chooses to visit the Museum of Science or not. For the timing and tracking maps and exit interviews, visitors that were thought to be 12 or older were chosen randomly as they entered (maps) or exited (interviews) the exhibitions. If the museum was busy, then approximately every third visitor over 12 was chosen. If the museum was not busy, then every visitor over 12 was chosen. Occasionally, data collectors misjudged the age of participants, so a few visitors between the ages of 10 and 12 were chosen.

Overall, participants, who were timed and tracked or interviewed, had similar demographics to those found in other Museum of Science studies including the *1999/2000 Visitor Study*¹. Fifty-nine percent of visitors were women and 59% of groups

¹ John Snow, Inc. (2000). *1999/2000 Visitor Study*. (Museum of Science Final Report). Boston: Author.

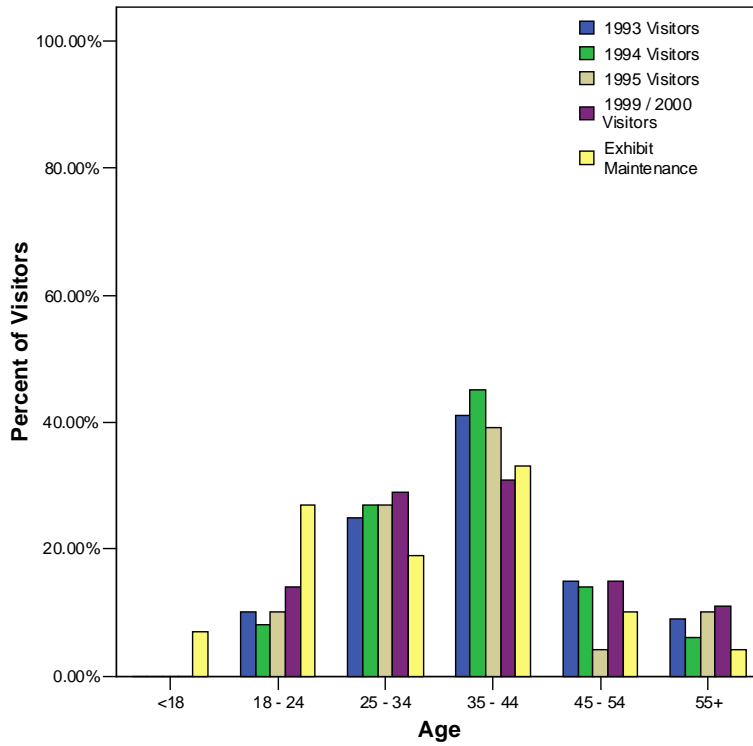
were composed of adults and children. However, only 47% of visitors in this study were 35 or older, and the other marketing studies have higher percentages for this age group. This is most likely because this study focused on visitors 12 and older not those 18 and older, so the ages of visitors skewed younger. Details of visitor participant demographics can be seen in Graphs 1-3.

Graph 1. Gender of Exhibit Maintenance Participants versus Marketing Studies²

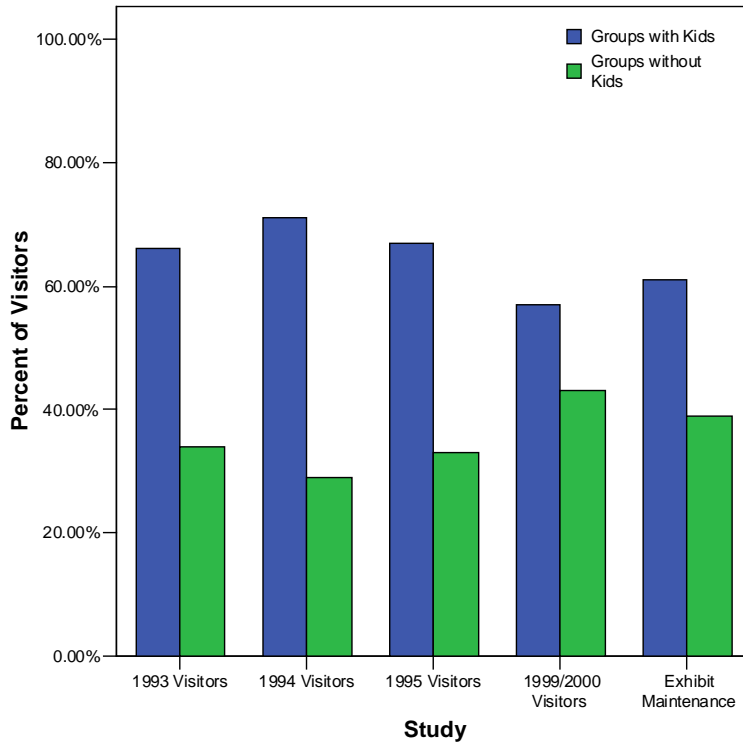


² All data except the Exhibit Maintenance data came from the 1999/2000 Visitor Study.

Graph 2. Age of Exhibit Maintenance Groups versus Marketing Studies³



Graph 3. Composition of Exhibit Maintenance Groups versus Marketing Studies³



³ All data except the Exhibit Maintenance data came from the 1999/2000 Visitor Study.

Recruitment was more difficult for the surveys and focus groups than the timing and tracking maps and exit interviews. The visitor surveys took at least 30 minutes to complete, so instead of recruiting visitors already in the Museum, visitors and internal museum groups were invited to fill out the surveys and participate in the focus group discussion. Two focus groups involved museum members and visitors, the majority of whom were over the age of 20. A total of nine people participated in these focus groups including one girl who was 7 years old. These people were recruited through the Museum's e-newsletter and Quark intranet and from University of North Carolina alumni lists. These groups were meant to represent the views of both frequent and infrequent visitors. Two other focus groups involved students from Fenway High School. These students come to the Museum once a week to volunteer in the eye-opener program and take science and technology-related classes. The 10th grade class was new to the Museum in September 2005, so they were asked to participate in order to get a young, fresh perspective of broken exhibits. The final pool of focus group participants consisted of interpretation volunteers. These volunteers come to the Museum about once a week and work on the floor explaining different science and technology phenomena to visitors. These volunteers were involved in three focus groups. The participants were meant to represent the perspective of people familiar with the Museum.

Finally, the Maintenance Department normally fills out surveys for different galleries in the Museum. Copies of these internal surveys were made in order to compare what the Maintenance Department calls broken to what the Fenway High School students, volunteers, and members and visitors call broken. The maintenance surveys that were analyzed were all collected around the same time as data were collected from the timing and tracking maps, exit interviews, and visitor surveys. The people who filled out the maintenance surveys represent many workers in the Exhibit Operations Department.

Evaluator Determination of Broken Exhibits

In order to compare the visitor data to any maintenance problems, evaluators tested exhibit functionality before, during, and after data collection. So that the evaluators would look at maintenance issues in the same way as the Maintenance

Department, a member of the Exhibit Operations staff trained the evaluator about how to detect broken exhibits in August 2005. The Exhibit Operations manager picked the maintenance worker, who conducted the training, because she was one of his most meticulous workers. A few exit interviews and timing and tracking maps were collected in *Seeing the Unseen* before the training; however, looking at the data, evaluator data collection did not change as a result of the training.

The maintenance worker taught the evaluator all the problems to look out for in the galleries, and how to test exhibits for problems. She told the evaluator that it was important to check all the exhibits in the galleries thoroughly. She said to check the buttons, audio, and headphones for problems, and that if any of these components were broken, then the entire exhibit was broken. For computers, buttons needed to work, the computers could not be too slow, and they could not have internal bugs that caused difficult use. Similar methods were used for non-computer exhibits. Specifically, if an exhibit was too slow, then she said it should be reported as broken. She also described the number of pieces needed for the exhibits in order for them to be functional. For example, she said the “Ping Pong Probability” in *Investigate!* needed 35 balls, and if there were fewer than 35 balls, the exhibit was broken. In addition, any rubbed out or ripped labels made an exhibit broken. Basically, if any part of an exhibit needed attention from maintenance workers, then it was described as broken by evaluators. An exhibit did not need to be completely non-functioning to be called broken by the evaluators.

Comment Card Report Protocol

Once or twice a month, the results of Museum of Science comment cards are compiled and presented on the Museum’s intranet known as Quark (<https://quark.mos.org/comments/>). Since concerns about the number of broken comments on the cards prompted this study, reports from January 1 – November 15, 2005 were analyzed to see how many of the comments were about broken or confusing exhibits and to see if there were any trends in what the cards said was broken. The number of comments about broken exhibits were counted and compared to the overall number of comment cards and comments. If possible, the gallery and specific exhibit

were recorded. In addition, the comments of visitors were sorted using inductive analysis, allowing categories to emerge from the data, to gain an understanding for the reasons why visitors called exhibits in the Museum broken.

Timing and Tracking Map Protocol

Timing and tracking maps were collected in *Making Models/Mapping the World Around Us* and *Seeing the Unseen* (see Appendix A). Fifty maps were collected in each of these galleries. Visitors over the age of 12 were randomly chosen as they entered the gallery in the manner discussed above. As the subject entered, the evaluator started a stopwatch to measure the total amount of time that the visitor stayed in the gallery. The evaluator also marked down the date, time of day, visitor gender, age, and group type. When a subject interacted with an exhibit (touched a button, picked up a hearphone, etc.) or stood in front of an exhibit for 10 seconds, the evaluator marked that exhibit on the map with an “X” indicating that the exhibit had been visited. As the subject left the exhibit, the stopwatch was stopped, and the subjects were approached and asked to participate in the exit interview (see Appendix B). After the end of the interaction with the subject, the evaluator filled in the survey number and the total elapsed time that the subject was in the gallery. Additionally, the gallery exhibits were checked before any maps were collected, approximately every 45 minutes – 1 hour during map/interview data collection, and at the end of data collection so that the evaluator could know which exhibits were broken in the gallery and to see if the status of any exhibits had changed during collection.

The timing and tracking maps were collected between August 19 and September 17, 2005. *Seeing the Unseen* was observed first, and data collection took place from August 19-27, 2005 during the week and on the weekend. Most of the data for this gallery were collected in the afternoon when the museum was most busy. Maps for *Making Models/Mapping the World Around Us* were collected between August 27 and September 17, 2005 during the week and the weekend. About half of the data were collected in the morning, and the rest were collected in the afternoon. For more information about where and when timing and tracking maps and interviews were collected see Appendix E.

Timing and tracking maps were collected in order to discover the popular exhibits in these galleries as well as to determine how many broken exhibits visitors encountered during their time in the galleries. Data were analyzed quantitatively using SPSS, and descriptive statistics were produced illustrating the attractiveness of exhibits, the percent downtime of exhibits, and the average number of times broken exhibits were visited.

Exit Interview Protocol

Exit interviews were conducted in all five galleries examined through this study: *Seeing the Unseen*, *Investigate!*, *Messages*, *Natural Mysteries*, and *Making Models/Mapping the World Around Us*. In total, 125 visitors were interviewed, with 25 visitors interviewed in each gallery (see Appendix B). The protocol for choosing these subjects was similar to the one employed for the timing and tracking study. Visitors were selected at random and asked if they would like to give the Museum feedback on exhibit design. The evaluator then explained that the interview was about the gallery that the visitor had just exited. If the visitor was willing to participate, the evaluator told the subject that they could stop at any time if they felt uncomfortable or did not want to continue; however, all participants completed the interview. Then the evaluator handed their clipboard over to the visitor so that they could fill out the first page of the interview on their own. When the visitor finished this page, the evaluator took back the clipboard and asked the visitor the questions on the other side. After the interview, the evaluator thanked the visitor for their time and then filled in the date, time of day, gallery, and survey number. In *Making Models* and *Seeing the Unseen*, the visitors selected to be interviewed represented a subset of those who had been tracked and timed. Timing and tracking maps and exit interviews, which concerned the same visitor, were given the same survey number. In the galleries where visitors were not timed and tracked (*Investigate!*, *Messages*, and *Natural Mysteries*) the evaluator checked the gallery before, during, and after the interviews for broken exhibits as described in the previous sections (see Appendix A and C).

Exit interviews were collected between August 17 and December 3, 2005. Exit interviews for *Seeing the Unseen* and *Making Models/Mapping the World Around Us* were collected at the same time as the timing and tracking maps. Exact dates can be

found in Appendix E. Interviews were collected in *Investigate!* from September 17 - October 8, 2005, in *Messages* from October 8 - 15, 2005, and *Natural Mysteries* from October 29 - December 3, 2005. The exit interviews for *Investigate!*, *Messages*, and *Natural Mysteries* were all collected on Saturdays. All of the *Messages* and *Investigate!* interviews were collected in the afternoon, and all of the *Natural Mysteries* interviews were collected in the morning.

The exit interviews were collected in order to find out the numbers and types of exhibits that visitors would call broken. In addition, the interviewers asked visitors about their enjoyment in the galleries as well as their disappointment in the number of broken exhibits in both the gallery and the Museum as a whole. In order to analyze this data, both qualitative and quantitative data methods were used. Descriptive statistics were used to illustrate the distribution and average number of exhibits called broken in each individual gallery. They were also used to describe the distribution and average enjoyment and disappointment of the visitors across the galleries. Inductive coding was used to analyze the qualitative data and discover the trends of why visitors called exhibits broken. Data were clumped until categories emerged, and then the quotations were counted in order to find out if visitors mentioned some maintenance issues more than others.

Visitor Survey and Focus Group Protocol

A mixture of volunteers, museum members, and visitors were asked to participate in a survey. Between 4 and 16 people were asked to fill out a survey for: *Messages*, *Making Models*, *Seeing the Unseen*, and *Investigate!* (see Appendix C and Table 2). The surveys contained a list of all the exhibits in a gallery. For the *Making Models* survey, exhibits from *Mapping the World Around Us* were excluded. Participants were asked to test all the exhibits on the list and mark whether the exhibit was working or not. If the exhibit was broken, then they were asked to explain how they determined it was broken. The process of going through an entire gallery took 30 minutes to 1 hour, so most participants were given either a free exhibit hall or Omnimax theater pass to thank them for their participation. Most of the survey participants were also asked to take part in a 30-minute focus group discussion after they completed the survey (see Appendix D).

The purpose of the discussion was to delve deeper into visitors' feelings about broken exhibits and to talk about their criteria for determining what is broken.

All of the focus groups took place between September 20 and October 25, 2005. Fenway High School students looked at all four of the survey exhibits on September 20, 2005. In the first session, five students tested exhibits in *Investigate!* and five tested exhibits in *Messages*. In the second session, 4 students tested *Seeing the Unseen*, and six students went to *Making Models*. On October 8, 2005, four Museum members (including a 7 year old and her father), and 1 visitor tested the exhibits in *Messages*. On October 15, 2005, four visitors recruited through a University of North Carolina alumni list and the Museum of Science Intranet participated in a focus group and tested the exhibits in *Making Models*. On October 13, 2005, Museum volunteers tested the exhibits in *Investigate!*, and on October 20, they discussed what they found. Volunteers visited *Making Models* on October 14, 2005, and talked about their findings on October 21. Finally, on October 18, 2005, volunteers tested the exhibits in *Messages*. On October 25, 2005, their findings were discussed. A summary of the number of people who participated in focus groups can be seen in Table 2.

The visitor surveys and focus group data were collected to get a better feel for what maintenance issues are of concern for visitors. It was decided that the volunteers would not be included in the survey data because their familiarity with the Museum made them unlike typical museum visitors. Though data from volunteers are not included with the surveys, their comments are included in with the focus group data. The primary purpose of the surveys was to compare them to maintenance surveys to find out if there were any discrepancies between the visitors and the maintenance workers. The exhibits called broken were compared to see if and why differences existed. The focus group data were analyzed through inductive methods in order to discover if any trends and important issues emerged from the discussions with visitors.

RESULTS

Comment cards, timing and tracking maps, exit interviews, visitor surveys, maintenance surveys, and focus groups were the many ways that information was collected to find out what visitors think about broken exhibits and how the broken exhibit problem can be improved. By using a wide variety of data sources, a more complete picture of the broken exhibit issue can be formed. Each instrument's data are treated separately here, and then the implications of the results are considered in the Discussion section.

Comment Card Reports

Major Trends in Comment Card Data:

- Overall, comments about broken exhibits appeared on about 13% of comment cards, and these comments were second only to customer service issues in 2005.
- There were no trends in which galleries visitors called broken.
- Most of the comments about broken exhibits were not specific. They just said that the exhibit was broken.
- A significant portion of the comments about broken and confusing exhibits concerned designs of exhibits that were not actually broken.

Table 3. Broken Comments on Comment Cards from January – November 2005

Year 2005	Broken Comments	Total Comments	Percent of Total Comments	Total Cards	Percent of Total Cards
January	0	15	0%	17	0%
February	4	30	13%	32	13%
March 1-15	0	12	0%	12	0%
April	4	40	10%	42	10%
May	4	31	13%	35	11%
June	5	26	19%	29	17%
July	4	24	17%	26	15%
August	6	45	13%	48	13%
September	5	19	26%	21	24%
October	7	39	18%	39	18%
November 1-15	3	20	15%	20	15%
Total	42	301	14%	321	13%

Over the course of 2005, the number of broken exhibit comments ranged from zero to seven per month. The highest percentage of comments occurred in September 2005, but the percentage might have been high because so few comment cards came in during that period. The cards from that month do not follow any sort of pattern, so the

comments do not seem to be the result of any particular maintenance issue. The highest number of comments was reported in October. This was the month when *Star Wars: Where Science Meets Imagination* opened, so Museum visitation was probably higher than normal Octobers. Still, once again, there does not seem to be any pattern among the comments. Overall, 42 comments out of the 301 in January – November 2005 were about broken exhibits. This is about 14% of the comments and 13% of the cards collected in 2005.⁴ This number is not very high, but a quick count of all the comments from 2005 showed that “broken” comments were second only to visitor service comments in terms of volume. For a more complete picture of the number of broken exhibit comments in 2005 see Table 3.

⁴ The numbers are different because visitors who fill out comment cards do not necessarily write down additional comments.

Table 4. Galleries/Exhibits Identified as Being Broken on January – November 2005 Comment Cards

	Number of Times Mentioned on Comment Cards	Percent of Broken Comments	Percent of Total Cards	Percent of Total Comments
Galleries in the Study				
<i>Natural Mysteries</i>	2	5%	1%	1%
<i>Mapping the World Around Us</i>	2	5%	1%	1%
<i>Investigate</i>	2	5%	1%	1%
<i>Seeing the Unseen</i>	1	2%	0%	0%
<i>Making Models</i>	1	2%	0%	0%
<i>Messages</i>	0	0%	0%	0%
Total	8	19%	2%	3%
Galleries not in the Study				
<i>A Bird's World</i>	3	7%	1%	1%
<i>Science in the Park</i>	3	7%	1%	1%
<i>Star Wars: Where Science Meets Imagination</i> ⁵	3	7%	1%	1%
<i>Current Science & Technology Stage Area</i>	2	5%	1%	1%
<i>The Lighthouse</i>	1	2%	0%	0%
<i>Mathematica</i>	1	2%	0%	0%
<i>Optical Illusions</i>	1	2%	0%	0%
<i>Rock Garden</i>	1	2%	0%	0%
<i>Butterfly Garden</i>	1	2%	0%	0%
<i>BRAIN: The World Inside Your Head</i> ⁶	1	2%	0%	0%
Total	17	40%	5%	6%
Other				
"Naboo Fighter"	2	5%	1%	1%
Wright 3D Theater	1	2%	0%	0%
Planetarium	1	2%	0%	0%
Total	4	10%	1%	1%
General Comment	16	38%	5%	5%

When broken exhibit comments were categorized by exhibition, no single exhibition stood out as a problem for visitors. For most of the comments, the exhibit that was broken could not even be determined. These 16 comments were composed of thoughts like, "The Museum isn't what it used to be. Too many exhibits weren't working when I last visited" (From October 16 – 31, 2005). They also included complaints about the general upkeep of the Museum. "We were very disappointed. Exhibits appear

⁵ "Star Wars: Where Science Meets Imagination" opened on October 27, 2005 and will close on April 30, 2006.

⁶ "BRAIN: The World Inside Your Head" opened on May 28, 2005 and closed on September 10, 2005.

‘dated’ and disorganized. Also, there is a great deal of dust on many exhibits adding evidence of neglect” (From June 1 - 15, 2005).

Overall, a total of 15 exhibitions, two theaters, and the “Naboo Fighter” in the Blue Wing were called broken over the course of 2005. The number of comments per gallery ranged from one to three and no gallery was singled out as having more problems than others. See Table 4 for more information on the exhibits called broken on comment cards.

Table 5. Reason Exhibits Were Called Broken on Comment Cards

Why was the exhibit called broken?	Number of Times Mentioned on Comment Cards	Percent of Broken Comments⁷	Percent of Total Cards	Percent of Total Comments
Maintenance Issue				
General	17	40%	5%	6%
No response / slow response	7	17%	2%	2%
Piece missing / need pieces	3	7%	1%	1%
Sign on it / roped off	2	5%	1%	1%
Other	1	2%	0%	0%
Total	30	71%	9%	10%
Design Issue				
Incorrect information on label	6	14%	2%	2%
Other	4	10%	1%	1%
No label	2	5%	1%	1%
Confusing label / directions	2	5%	1%	1%
Exhibit difficult to use	1	2%	0%	0%
Total	15	36%	5%	5%
Other Problems				
Exhibit dirty	3	7%	1%	1%
Exhibit / museum in bad shape	3	7%	1%	1%
Exhibit old / out of date	2	5%	1%	1%
Total	8	19%	2%	3%

Some trends did emerge when looking at the types of problems that prompted visitors to report exhibits as broken on comment cards (see Table 5). A majority of the comments (71%) involved exhibits in need of repair. The most common reason (40%) was a general “it’s broken” response. These included comments like: “Twenty five

⁷ These numbers add up to more than 100% because some comments discussed more than one broken exhibit issue.

percent of the exhibits were out of order” and “Planetarium: Stonehenge solstice didn't work.”

Another relatively large proportion of broken or confusing exhibit issues (36%) had to do with the design of the exhibit. A majority of these design problems had to do with exhibit labels. The label problems made up 24% of the problems recognized by visitors. A common complaint was incorrect information on the labels. One of the comments concerned information provided in *A Bird's World*: “Fresh water habitat birds display has lots of errors. Have a real ornithologist check all your birds in all habitats” (From September 1 – 15, 2005). Another comment talked about an explanation of vaccination in *Making Models*.

I was at the Museum Wednesday with my family. We visited the Making Models exhibit. There is a very serious error in the exhibit which simulates decision making - selfish vs. community conscious. The last example states that people who receive a flu shot are being selfish because it creates resistant strains of flu. THIS IS ABSOLUTELY WRONG. This may be true of antibiotic use but not of vaccination. Vaccination decreases the pool of virus in the population decreasing the chance of infection for everyone. In fact, people who DO NOT get vaccinated are selfishly counting on the general population being vaccinated to protect them. The problem is that if even a few people do not get vaccinated, it exposes everyone to the disease, even those have been vaccinated but who do not have a strong immune response to the shot. They will also get the disease.

(From February 16 – 28, 2005)

Other label problems include missing or confusing labels. One complaint involved the lack of labels for taxidermy objects in *Natural Mysteries*. “The Natural Mysteries Room has beautiful cats up above. Please identify them. There were several families, along with me, that didn't know whether we were looking at a cheetah, leopard, panther, etc...Thanks” (From May 16 – 31, 2005). Another comment discussed confusion about the directions of one of the activities. “Making Models. Rotating island - signage - E/W/N/S - not clear if direction looking [sic] or side of island” (From October 16 – 31, 2005).

Timing and Tracking Maps and Exit Interviews

Major Trends in Timing and Tracking Map and Exit Interview Data:

- Visitors in exit interviews did not report most of the broken exhibits that they encountered as broken.
- Visitors were not likely to call partially functional exhibits broken.
- Visitors were more likely to report computer-based exhibits broken than others.
- Though a majority of “broken” exhibits had maintenance issues, design problems were also an important reason why exhibits were called broken.
- More broken exhibit issues were seen in the three older exhibitions (*Investigate!*, *Messages*, and *Seeing the Unseen*) than the two younger ones (*Making Models* and *Natural Mysteries*). Visitors found and called more broken, there were higher downtimes, visitors were more disappointed in the broken exhibits in these galleries, and they enjoyed their experience there less.

Why Are Exhibits Called Broken by Visitors?

Table 6. The Number of Exhibits Called Broken by Visitors in the Five Galleries

	Number of Exhibits Called Broken by Visitors	Total Number of Exhibits in the Gallery	Percent of Exhibits Called Broken by Visitors
<i>Seeing the Unseen</i>	10	54 – 55 ⁸	18%
<i>Investigate!</i>	8	35	23%
<i>Messages</i>	7	21	33%
<i>Natural Mysteries</i>	3	69	4%
<i>Making Models</i>	6	59	10%
Total	34	239	14%

Overall, 10 exhibits in *Seeing the Unseen*, six exhibits in *Making Models/Mapping the World Around Us*, eight exhibits in *Investigate!*, seven exhibits in *Messages*, and three exhibits in *Natural Mysteries* were identified as broken by visitors. These 34 exhibits represent a total of 14% of all the exhibits in the five galleries illustrating that overall visitors were not calling very many exhibits broken. However, it is interesting to note that higher percentages of exhibits were called broken in the three older galleries: *Seeing the Unseen*, *Investigate!*, and *Messages* (see Table 6).

⁸ For half of the study, *Seeing the Unseen* had 54 exhibits, and for the other half, it had 55 exhibits.

Table 7. Natural Mysteries Exhibits Identified as Broken by Visitors or Evaluators

	Number of Visitors Who Called the Exhibit Broken (N=25)	Percent of Visitors Who Called the Exhibit Broken	Number of Times Evaluator Called the Exhibit Broken (N=25)	Percent of Times Evaluator Called the Exhibit Broken ⁹	Reason Evaluator Called the Exhibit Broken	Reason Visitor Called the Exhibit Broken
Natural Mysteries						
Computers						
Mountain Lion Tracks	4	36%	7	28%	No function	No function
Classify in the Clay	0	0%	7	28%	No function	N/A
Collections Computers	0	0%	18	72%	Partially functional: Error message / Non-functional	N/A
Mammal Skull Mystery	0	0%	25	100%	Partially functional: Teeth broken on skulls	N/A
Not sure which one	2	18%	N/A	N/A	N/A	N/A
Activities						
Make Your Own Museum	1	9%	1	4%	Partially functional: Missing chalk	No empty boxes
All Sorts of Minerals	0	0%	7	28%	Partially functional: One door off track	N/A
Periodic Table	0	0%	18	72%	Partially functional: Plexiglas sign is loose	N/A
School Blackboard	0	0%	10	40%	Partially functional: Eraser missing	N/A
School Bookshelf	0	0%	12	48%	Partially functional: No pencil or eraser	N/A
Static Objects						
Where Did All This Come From?	1	9%	0	0%	N/A	Missing object / Design issue: Incorrect information on label
Chinese Herb Cabinet	0	0%	25	100%	Partially functional: Plexiglas cracked	N/A
Chinese Herb Table	0	0%	11	44%	Partially functional: Smells weak	N/A
Eggs Cabinet	0	0%	19	76%	Partially functional: Plexiglas broken / egg loose	N/A
Pots Cabinet	0	0%	5	20%	Partially functional: Plexiglas cracked	N/A
Rocks in your Socks	0	0%	25	100%	Partially functional: Labels loose and unglued	N/A
Shells Cabinet	0	0%	19	76%	Partially functional: Shell loose in drawer	N/A
Shells 2 Cabinet	0	0%	19	76%	Partially functional: Screw is loose in cabinet	N/A
Shell Drawers	0	0%	19	76%	Partially functional: Drawers will not stay closed	N/A
Unknown Drawers	1	9%	N/A	N/A	N/A	Drawers empty
Audio Labels						
Unknown Audio Label	1	9%	N/A	N/A	N/A	N/A
Unknown	1	9%	N/A	N/A	N/A	N/A

⁹ These percentages are equal to the number of exit interviews when the exhibit was broken divided by the total number of exit interviews (N=25).

Table 8. Seeing the Unseen Exhibits Identified as Broken by Visitors or Evaluators

Seeing the Unseen	Number of Visitors Who Called the Exhibit Broken (N=25)	Percent of Visitors Who Called the Exhibit Broken	Number of Visitors Who Stopped at the Exhibit (N=50)	Percent of Visitors Who Stopped at the Exhibit	Number of Times Evaluator Called the Exhibit Broken (N=50)	Percent of Times Evaluator Called the Exhibit Broken ¹⁰	Reason Evaluator Called the Exhibit Broken	Reason Visitor Called the Exhibit Broken
Microscopes								
Insect-Earthly Aliens	2	13%	14	28%	35	70%	Partially functional: Label missing / No function	No function
Life in a Drop of Pondwater	1	6%	6	12%	32	64%	Partially functional: Label missing / No function	No function
Bring Your Own Stuff	1	6%	9	18%	35	70%	Partially functional: Piece missing / No Function	Design issue: Difficult to Use
Not sure which one	2	13%	N/A	N/A	N/A	N/A	N/A	No function
Activities								
Piano Strobe	2	13%	29	58%	0	0%	N/A	Design issue: Expected result unclear
Splash in a Flash	2	13%	12	24%	20	40%	No function / slow function	No function
Color Reversal	1	6%	17	34%	9	18%	No function	No function
Hearing Range	1	6%	12	24%	0	0%	N/A	Design issue: Expected result unclear
Infrared Camera	1	6%	23	46%	0	0%	N/A	Exhibit needs an upgrade
Smell Survey	1	6%	13	26%	9	18%	Partially functional: Some smells not working	Design issue: Difficult to Use
Reflecting Pond	1	6%	20	40%	0	0%	N/A	Design issue: Expected result unclear
Bioscanner	0	0%	23	46%	3	6%	Partially functional: Video screen broken	N/A
Leonardo's Window	0	0%	14	28%	7	14%	Partially functional: Marker almost out of ink	N/A
Playing with Polarizing Light Table	0	0%	19	38%	50	100%	Partially functional: Lever piece broken	N/A
Visible Effects of the Invisible	0	0%	20	40%	9	18%	Partially functional: Counter chipped	N/A
Unknown	1	6%	N/A	N/A	N/A	N/A	N/A	N/A

¹⁰ These percentages are equal to the number of timing & tracking maps when the exhibit was broken divided by the total number of timing & tracking maps (N=50).

Tables 7 and 8 illustrate the fact that visitors often missed maintenance problems that left an exhibit partially functional while they caught problems that made an exhibit non-functional. This meant that visitors did not find most of the maintenance issues found by evaluators. Fifty-nine percent of the exhibits called broken by evaluators were not called broken by visitors. Though these two tables display the broken exhibits called broken by visitors and evaluators in only *Seeing the Unseen* and *Natural Mysteries* similar results are seen in the tables for the other galleries (see Appendix G). Of the 34 exhibits called broken by visitors in all the galleries, 16 had no function while only four with partial function were called broken. Another 14 exhibits identified by visitors as broken had design or other non-maintenance issues. In addition, of the exhibits called broken by evaluators but not visitors, 46 were partially functional while only three were non-functional. This illustrates that visitors were focused on non-functional exhibits, but did not care as much about maintenance issues as long as they could interact with an exhibit to some degree.

Sometimes problems beyond Maintenance's scope caused visitors to think that an exhibit was non-functional. Design issues occasionally caused visitors to think that exhibits were not working. In *Making Models*, the "What Time Is It?" exhibit was called broken by one visitor because the fact that "no lights [were] on" meant that the exhibit was not functioning (Interview #56). As a result of this design, she did not even approach the exhibit. In a different case, a visitor said that "A Visual Language" video was broken because "the screen was blank," a complaint similar to the previous example (Interview #151). Therefore, it is important that exhibits be designed so that they appear to be functioning at all times, even if they are not currently being used.

Table 9. Number of Times Visitors Called Different Types of Exhibits Broken

	Number of times exhibits were called broken by visitors	Percent of times exhibits were called broken by visitors
Computer-Based Exhibits		
Computers	26	33%
Electric Exhibits		
Electricity-Based Activities	22	28%
Microscopes	6	8%
Audio Labels	1	1%
Video	1	1%
Non-Electric Exhibits		
Non-Electricity-Based Activities	12	15%
Static Objects	2	3%
Unknown Exhibits	10	13%

Table 10. Number of Computer-Based Exhibits Called Broken by Visitors

	Number of Computer-Based Exhibits Called Broken by Visitors	Number of Computer-Based Exhibits in Gallery	Percent of Computer-Based Exhibits Called Broken by Visitors
<i>Seeing the Unseen</i>	0	6	0%
<i>Investigate!</i>	3	11	27%
<i>Messages</i>	4	14	29%
<i>Natural Mysteries</i>	1	7	14%
<i>Making Models</i>	2	7	29%

Computer-based exhibits were often the type of exhibit called out by visitors as having maintenance problems. Of the 80 times that exhibits were called broken by visitors, 33% of the comments were about computer-based exhibits (Table 9). For three of the exhibits (*Investigate!*, *Messages*, and *Making Models*), over 25% of the exhibits called broken were computer-based (see Table 10). This is a large percentage of the exhibits in the galleries considering that only 19% of all the exhibits in all five galleries are computers, and that only 31% of *Investigate!* and 18% of *Making Models/Mapping the World Around Us* is made up of computer-based exhibits. These numbers demonstrate that visitors are describing problems with broken computers frequently.

Table 11. The Number of Computer-Based Exhibits Called Non-Functional and Partially Functional by Evaluators

	Number of Computer-Based Exhibits in Gallery	Number of Computer-Based Exhibits Called Non-functional by Evaluators	Percent of Computer-Based Exhibits Called Non-functional by Evaluators	Number of Computer-Based Exhibits Called Partially Functional by Evaluators	Percent of Computer-Based Exhibits Called Partially Functional by Evaluators
<i>Seeing the Unseen</i>	6	0	0%	0	0%
<i>Investigate!</i>	11	5	45%	5	45%
<i>Messages</i>	14	4	29%	4	29%
<i>Natural Mysteries</i>	7	3	43%	1	14%
<i>Making Models</i>	7	2	29%	2	29%

The reason that visitors have so much trouble with computers is the fact that they are often likely to be non-functional. Across all the galleries, there were at least as many computers called non-functional as those called partially functional by evaluators (see Table 11). As discussed above, visitors are more likely to call an exhibit broken if it has no function, so it makes sense that the high numbers of non-functioning computers are noticed by visitors. By comparing Table 10 and 11, it is discovered that the number of computers called broken by visitors is very close to the number of computers called non-functional by evaluators. In addition, it was observed that visitors were much more likely to call computers broken when they could not be used than when they had broken buttons or internal computer bugs that allowed partial use. Therefore, the reason visitors have more problems with computers as opposed to other types of exhibits is the fact that they are likely to be non-functional.

Table 12. Reasons Why Visitors Called Exhibits Broken on Exit Interviews

Reason Exhibits Were Called Broken	All Galleries		Seeing the Unseen		Investigate!		Messages		Natural Mysteries		Making Models	
	Number of Visitors	Percent of Visitors ¹¹	Number of Visitors	Percent of Visitors ¹¹	Number of Visitors	Percent of Visitors ¹¹	Number of Visitors	Percent of Visitors ¹¹	Number of Visitors	Percent of Visitors ¹¹	Number of Visitors	Percent of Visitors ¹¹
Nothing was broken	70	56%	13	52%	9	36%	13	52%	16	64%	19	76%
Maintenance issue	44	35%	6	24%	16	64%	9	36%	8	32%	5	20%
Design issue	12	10%	5	20%	1	4%	2	8%	2	8%	2	8%
It is chronically broken	2	2%	0	0%	2	8%	0	0%	0	0%	0	0%
I don't remember what was broken	11	9%	1	4%	5	20%	3	12%	2	8%	0	0%

Table 13. Maintenance Issues Described by Visitors on Exit Interviews

Maintenance Issues	All Galleries		Seeing the Unseen		Investigate!		Messages		Natural Mysteries		Making Models	
	Number of Comments	Percent of Maintenance Comments	Number of Comments	Percent of Maintenance Comments	Number of Comments	Percent of Maintenance Comments	Number of Comments	Percent of Maintenance Comments	Number of Comments	Percent of Maintenance Comments	Number of Comments	Percent of Maintenance Comments
No function / slow function	28	53%	6	100%	6	29%	9	75%	4	44%	3	60%
Sign on it / roped off	8	15%	0	0%	8	38%	0	0%	0	0%	0	0%
General comment	8	15%	0	0%	4	19%	1	8%	3	33%	0	0%
Piece missing / need pieces	7	13%	0	0%	3	14%	0	0%	2	22%	2	40%
I saw maintenance working on it	1	2%	0	0%	0	0%	1	8%	0	0%	0	0%
Hearphone / audio not working well	1	2%	0	0%	0	0%	1	8%	0	0%	0	0%

Table 14. Design Issues Described by Visitors on Exit Interviews

Design Issues	All Galleries		Seeing the Unseen		Investigate!		Messages		Natural Mysteries		Making Models	
	Number of Comments	Percent of Design Comments	Number of Comments	Percent of Design Comments	Number of Comments	Percent of Design Comments	Number of Comments	Percent of Design Comments	Number of Comments	Percent of Design Comments	Number of Comments	Percent of Design Comments
Activity difficult to use	6	43%	4	57%	1	100%	1	50%	0	0%	0	0%
Expected result unclear	5	36%	3	43%	0	0%	1	50%	0	0%	1	50%
Incorrect information on label	1	7%	0	0%	0	0%	0	0%	1	50%	0	0%
Drawers empty	1	7%	0	0%	0	0%	0	0%	1	50%	0	0%
Thought it had no power	1	7%	0	0%	0	0%	0	0%	0	0%	1	50%

¹¹ The total is greater than 100% because some visitors described more than one broken exhibit issue during the exit interview.

Many visitors did not find any broken exhibits in the five study galleries; however, when they did, they were more likely to find maintenance issues than design issues. Tables 12, 13, and 14 display the reasons visitors gave for how they determined an exhibit was broken. The tables show that over half of the visitors did not find any broken exhibits in the study exhibitions. Still, when broken exhibits were found, the reasons that visitors called something broken fell into certain patterns. Of the 35% of interviews where maintenance problems were identified, the most common problem (53% of maintenance issues) was that the visitor said the exhibit had no function or that they could not elicit a response from the exhibit. These problems included issues with buttons like, “Clicking the buttons didn’t do anything” (Interview #150). They also included times when visitors could not induce a reaction from an activity. “It did not drip” (Interview #33). Another common problem was with computers. “I noticed the computer was frozen” (Interview #64). Non-function was the most common reason that people called exhibits broken in every exhibition except *Investigate!* In *Investigate!*, most visitors (38% of maintenance issues) reported that they knew an exhibit was broken because they noticed signs or ropes around exhibits.

Though maintenance problems were most common, 10% of “broken” exhibit interviews concerned the exhibits’ designs. Most of these comments stated that the exhibits that were difficult to use or produced an outcome unexpected by the visitor. Examples of this type of issue include, “Zoom wasn’t working—it wouldn’t focus” (Interview #18). This quote is in reference to the “Bring Your Own Stuff” microscope in *Seeing the Unseen*. The “Piano Strobe” in *Seeing the Unseen* also caused problems for visitors. “Strobe frequency wasn’t right. Maybe I didn’t understand it. Maybe it was me” (Interview #18).

Though difficult to use exhibits were the most common design problems for most of the galleries, label problems were more prevalent in *Making Models/Mapping the World Around Us* and *Natural Mysteries*. These problems did not constitute all of the design problems found in the exhibitions, but they did constitute two of the four design comments from the two galleries. One comment about labels discussed a missing taxidermy object in *Natural Mysteries*. “Beaver is missing from the exhibit. Another animal is there and doesn’t match the card” (Interview #173). In *Mapping the World*

Around Us, one visitor thought a label for the “Mt. Champlain Trails” exhibit referred to the large Mt. Everest model. “Yellow light up mountain—light did not go on” (Interview #64). These comments show that when static objects or models compose large portions of a gallery, labels may become more important to visitors than in hands-on exhibits. Visitors also identified other design issues, but none of them occurred more than once.

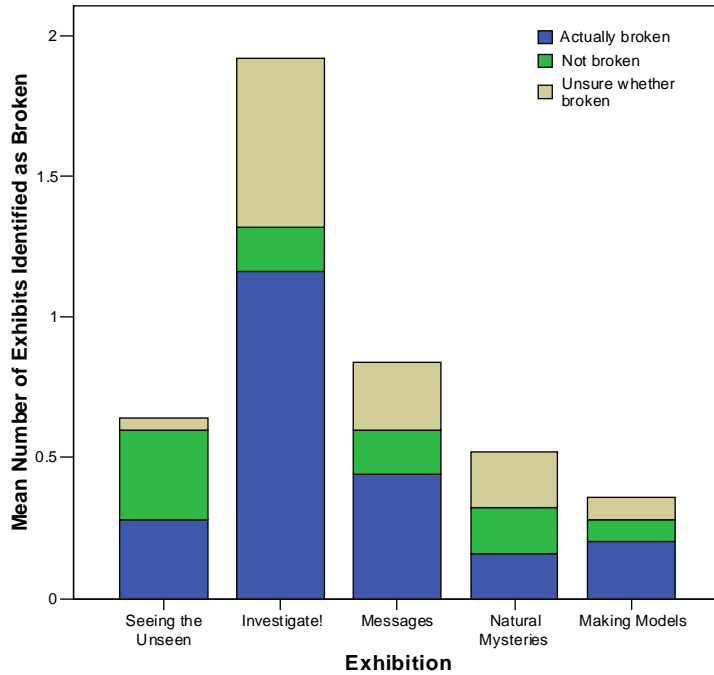
Cross-Gallery Comparisons

Table 15. Interviewed Visitors Who Identified Exhibits as Broken

	Year Opened	Number of Visitors Who Reported Broken Exhibits	Percent of Visitors Who Reported Broken Exhibits
<i>Seeing the Unseen</i>	1991	12	48%
<i>Investigate</i>	1996	16	64%
<i>Messages</i>	1999	12	48%
<i>Natural Mysteries</i>	2000	9	36%
<i>Making Models</i>	2003	6	24%
Total		55	44%

Across the five study galleries, we see a wide variation in the percent of visitors, who identify one or more exhibits as broken, with more visitors identifying exhibits as broken in the older exhibits than the newer ones (see Table 15). The three exhibitions with the highest percentage of visitors finding broken exhibits were also the three oldest exhibitions: *Investigate!* (64%), *Seeing the Unseen* (48%), and *Messages* (48%). In the two newer galleries, less than 40% of visitors found any broken exhibits: 36% of visitors in *Natural Mysteries* and only 24% of visitors in *Making Models / Mapping the World Around Us*.

Graph 6. Number of Exhibits Identified as Broken During Interviews



Besides being more likely to find broken exhibits in the three older galleries, visitors to these galleries were also more likely to call a greater number of exhibits broken. Graph 6 shows that the average number of exhibits called broken by visitors in the five study galleries. It illustrates that visitors to the oldest three galleries reported the highest numbers of broken exhibits, and that the number of broken exhibits increases with age of gallery with the exception of *Seeing the Unseen*.

Table 16. Range of Exhibits Called Broken by Visitors During Exit Interviews

Gallery	Minimum Number of Exhibits Called Broken By Visitors	Maximum Number of Exhibits Called Broken by Visitors	Average Number of Exhibits Called Broken by Visitors
<i>Seeing the Unseen</i>	0	2	0.58
<i>Investigate!</i>	0	7	1.92
<i>Messages</i>	0	3	0.8
<i>Natural Mysteries</i>	0	3	0.52
<i>Making Models / Mapping the World Around Us</i>	0	3	0.36

While the average number of exhibits reported broken by visitors increased with age, looking at the range of exhibits called broken by visitors it is seen that the five

galleries did not vary that much (Table 16). The main exception is *Investigate!* where some visitors said that seven exhibits were broken. This number is much higher than any of the other gallery maximums. This demonstrates that if there are a lot of broken exhibits in a gallery, then visitors will report a higher number. If the number of broken exhibits is more moderate, then the number reported broken by visitors seems to max out at about three. However, the number of visitors who report broken exhibits will increase with exhibit downtimes and design issues. By comparing the maximums to the ranges, it is discovered that quite a few people found exhibits broken in *Seeing the Unseen* and *Messages*. Fewer people found broken exhibits in *Natural Mysteries*, and even fewer visitors found broken exhibits in *Making Models / Mapping the World Around Us*.

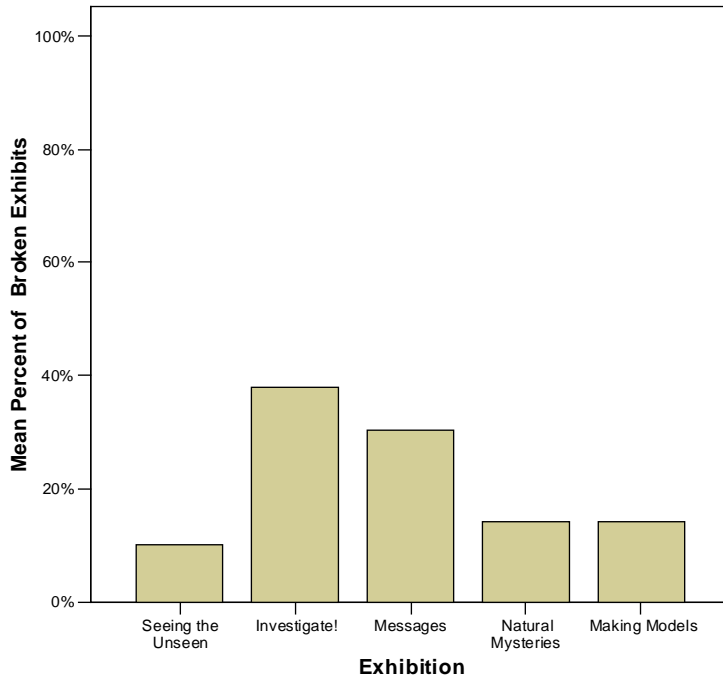
Table 17. Range of Exhibits Called Broken by Visitors Compared to Evaluators

Gallery	Range of Exhibits Called Broken by Visitors When Called Broken by Evaluators	Range of Exhibits Called Broken by Visitors When Not Called Broken by Evaluators	Range of Exhibits Called Broken by Visitors Not Sure If Called Broken by Evaluators
<i>Seeing the Unseen</i>	0 - 2	0 - 2	0 - 1
<i>Investigate!</i>	0 - 5	0 - 1	0 - 5
<i>Messages</i>	0 - 3	0 - 1	0 - 3
<i>Natural Mysteries</i>	0 - 1	0 - 2	0 - 2
<i>Making Models / Mapping the World Around Us</i>	0 - 1	0 - 1	0 - 1

Graph 6 also illustrates that some of the exhibits that visitors identified as broken were not broken. The graph reveals that in certain galleries visitors were more likely to find design problems or other issues that caused them to report that an exhibit was broken. Table 17 illustrates the range of the number of exhibits called broken by visitors compared to the reports of evaluators. It shows that in *Investigate!* and *Messages* visitors were more likely to report maintenance problems found by evaluators than those not reported by evaluators. It also shows that visitors were just about as likely to report “broken” exhibits found by evaluators as those not reported by evaluators in *Seeing the Unseen* and *Making Models / Mapping the World Around Us*. Finally, in *Natural Mysteries*, some visitors reported more broken exhibit issues than those found by evaluators. These numbers are important because they show that visitors are calling

some exhibits broken for reasons other than maintenance and that this occurs in some galleries more than others.

Graph 7. Average Percent of Exhibits Broken During Interviews



Just as with the average number of exhibits called broken by visitors, evaluators found that the average downtime of exhibits increased with age though *Seeing the Unseen* was an exception (Graph 7). Two of the older galleries, *Investigate!* and *Messages*, had averages of 30% or more exhibits being broken at the time of the exit interviews. *Investigate!* had an average exhibit downtime of 38%, and *Messages* had an average downtime of 30%. The two newer galleries, *Natural Mysteries* and *Making Models / Mapping the World Around Us*, both had average downtimes of less than 14%. In this case, *Seeing the Unseen* breaks the trend of older galleries having worse broken exhibit problems. This exhibit had the lowest average of any exhibition with an average downtime at 10%.

Visitor Disappointment in the Number of Broken Exhibits

Graph 8. Average Visitor Disappointment in Broken Exhibits by Gallery

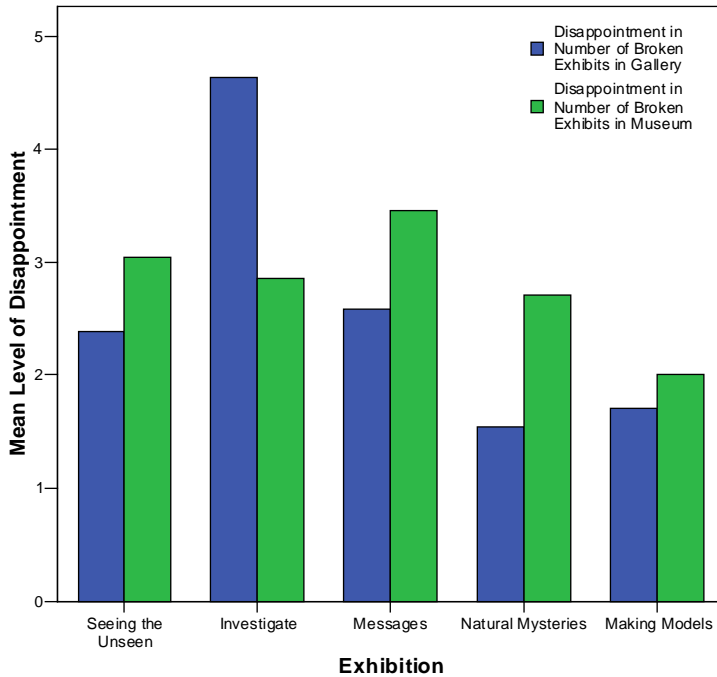


Table 18. Visitor Ratings of Disappointment in Number of Broken Exhibits in Galleries

Visitor Disappoint in Number of Broken Exhibits in the Gallery	Low Disappointment (Rated 1 – 4)	Moderate Disappointment (Rated 5)	High Disappointment (Rated 6 – 10)
<i>Seeing the Unseen</i>	76%	14%	10%
<i>Investigate!</i>	46%	23%	32%
<i>Messages</i>	83%	8%	8%
<i>Natural Mysteries</i>	96%	4%	0%
<i>Making Models / Mapping the World Around Us</i>	92%	8%	0%

The level of disappointment that visitors felt in both the galleries and the entire Museum seemed to be related to the age of the exhibition. Graph 8 shows that people had higher levels of disappointment in the three older exhibitions than the two newer ones. *Investigate!* had the highest number of broken exhibits, more visitors identified broken exhibits there, and they found a higher number of broken exhibits. People were also most disappointed in the number of broken exhibits in this exhibition (average of 4.64 out of 10), and they were more likely to give it a ranking of six or more. Thirty-two

percent of visitors ranked the gallery six or higher which is higher than the high rankings for all the other galleries combined. The average disappointments for *Messages* (2.58) and *Seeing the Unseen* (2.38) were also high compared to the two newer exhibitions. In addition, they had higher numbers of people ranking them a five or above (see Table 18). Twenty-four percent of visitors ranked *Seeing the Unseen* five or above, and 16% ranked *Messages* five or above compared to 12% of the visitors to *Making Models/Mapping the World Around Us* and *Natural Mysteries* combined. When the galleries were newer, the average disappointment was less than two: *Making Models/Mapping the World Around Us* had an average of 1.71, and *Natural Mysteries* had an average of 1.54. In these two cases, over 90% of visitors ranked the galleries in the lower end of the scale. There is a significant difference between visitor disappointments in the number of broken exhibits in the five study galleries ($\chi^2 = 52.35$, $df = 32$, $p = 0.013$).

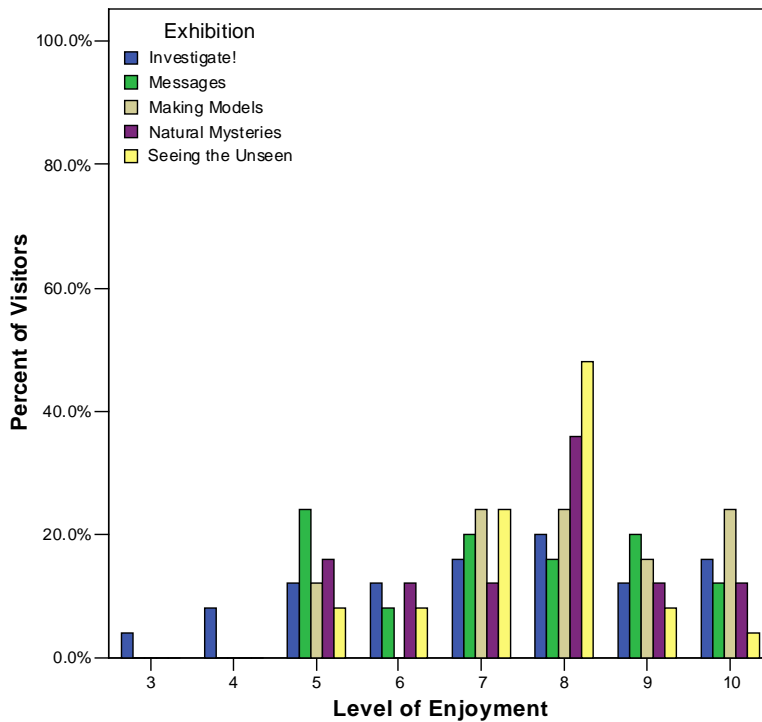
Table 19. Visitor Ratings of Disappointment in Number of Broken Exhibits in the Museum

Visitor Disappoint in Number of Broken Exhibits in the Museum	Low Disappointment (Rated 1 – 4)	Moderate Disappointment (Rated 5)	High Disappointment (Rated 6 – 10)
<i>Seeing the Unseen</i>	76%	19%	5%
<i>Investigate!</i>	73%	18%	9%
<i>Messages</i>	67%	21%	13%
<i>Natural Mysteries</i>	79%	13%	8%
<i>Making Models / Mapping the World Around Us</i>	96%	4%	0%

Overall, visitors tended to be more disappointed in the Museum as a whole than in individual galleries. *Investigate!* is the only exhibition where visitors were more disappointed in the number of broken exhibits in that gallery (average of 4.64 out of 10) than in the entire museum (average of 2.86 out of 10). Visitors to the other four exhibitions showed higher disappointment in the number of broken exhibits in the Museum than in the gallery. *Messages* had the highest average disappointment in the number of broken exhibits in the Museum of all the study exhibitions (3.46 out of 10), and 34% of visitors gave it a ranking of 5 or above. *Seeing the Unseen* also had an average of above 3 (3.05 out of 10), and it had a high number of visitors ranking it five or above (24%). While *Making Models/Mapping the World Around Us* (2.00 out of 10) and

Natural Mysteries (2.71 out of 10) both had average disappointments in the number of broken exhibits in the Museum of less than three as well as the smallest percentage of people ranking it a 5 or above. Still, there was not a significant difference between the galleries and visitor disappointment in the Museum. Nevertheless, it appears that age of the exhibition may have had some influence on the results of this question.

Graph 9. Level of Enjoyment in Galleries



The average enjoyments reported by visitors to the five exhibitions were all very similar. The average ranged from 7.16 – 8.04. So, overall, the enjoyments of visitors in the exhibitions were similarly high. Still, some interesting data came out of the question. *Investigate!* was the only exhibition that was rated below a five by visitors. Three out of the 25 interviewed visitors (12%) rated the gallery a three or four. All of the other exhibitions had value ranges of five to ten, which is a normal range of responses for most surveys exploring visitors’ experiences at the Museum of Science. Therefore, on a five to ten scale, it can be assumed that five to seven is the lower end of the scale, and eight to ten is the higher end of the scale. Based on this assumption, it is seen that two of the

exhibitions had 52% of visitors ranking their enjoyment a seven or below: *Investigate!* and *Messages*. While three exhibitions had 40% or less visitors ranking them a seven or below: *Making Models/Mapping the World Around Us* (36%), *Natural Mysteries* (40%), and *Seeing the Unseen* (40%). This data again follows age lines with *Investigate!* and *Messages* showing lower scores. However, once again, *Seeing the Unseen* does not follow this trend, so age cannot be the only factor leading to enjoyment for visitors. Though some exhibits were more enjoyable for visitors than others, this difference is not statistically significant. A breakdown of how visitors ranked their enjoyment can be seen in Graph 9.

Visitor and Maintenance Surveys and Focus Groups

Major Trends in Visitor and Maintenance Surveys and Focus Group Data:

- There are internal inconsistencies in what exhibit maintenance workers call broken.
- Maintenance is good about reporting non-functional or chronically broken exhibits, but they often miss content problems and computer bugs.
- From the visitor surveys, there emerge design and usability issues.
- The maintenance workers noticed some mechanical, electrical, and construction problems that visitors missed.
- During focus groups, specific problems involving buttons and audio labels emerged that did not seem as troublesome based on surveys alone.
- The most discussed exhibit problems at focus groups were computer bugs and exhibit design issues.

The following two surveys came from maintenance workers who checked one of the study galleries on two consecutive days (Table 20 and 21). The two surveys illustrate the opposite ends of the exhibit maintenance report spectrum. The maintenance worker from the first survey called a number of things broken and also made note of potential problems that should be attended to. These problems included changes to the labels and chronic issues that come up during regular maintenance of the exhibition. The worker even added five interactives that are not on the original sheet. The maintenance worker went into great detail, and the changes that need to be made to the exhibits were very clear.

The second maintenance survey is from the very next day. This maintenance worker marked everything as working even though it was not possible that all the broken exhibits from the 3MS survey were fixed. Another problem was that the worker used cryptic language in the one note that was included. “Cracked plexiglass [sic]” probably refers to a corner of the Plexiglas on that was broken on one of the exhibits (noted in the 4MS survey); however, this note is only useful if everyone who utilizes the maintenance surveys can understand it.

Table 20. Maintenance Survey 3MS

Gallery #1

Date: Day 1
Survey: 3MS

Exhibit Name	Type	Status		Nature of the Problem
		OK	N.R.	
Right Wall Activities				
Exhibit #3	animals	X		NEED NEW LAMENATED SHEET AND SPARES
Exhibit #56	graphic	X		
Exhibit #4	activity	X		
Exhibit #6	graphic	X		GRAPHIC ON LEFT NEEDS LITE-- BLOCKED BY EXHIBIT #8
Exhibit #12	activity	X		
Exhibit #13	activity	X		
Exhibit #14	activity	X		
Exhibit #15	activity	X		
Exhibit #16	video & graphic	X		
Exhibit #19/20	activity	X		
Back Wall Activities				
Exhibit #21	computer	X		
Exhibit #23	demonstration unit	X		
Exhibit #24	video	X		KEEP AN EYE: VISITORS TURN OFF MONITOR
Middle Activity Area- Near Exhibition Entrance				
Exhibit #50	activity		X	NEEDS ... NEW FEET
Exhibit #53	graphic	X		
Exhibit #52	computer	X		
Exhibit #51	activity	X		
Exhibit #7	activity	X		

Exhibit #8	activity		X	1) KNOB IS GONE AGAIN; 2) LITE OUT IN CASE
Exhibit #49	activity		X	1 SIDE LEVER NOT CONNECTED
Exhibit #48	activity	X		
Exhibit #47	activity	X		
Exhibit #11	activity	X		
Exhibit #45	activity	X		ADD GRAPHIC ... WOULD HELP VISITORS
Exhibit #44	activity	X		UPDATE AUDIO TEXT ...
Exhibit #46	activity		X	SHOULD [CHANGE] ... RANGE ...
Middle Activity Area- In the Back of the Exhibition				
Exhibit #39	activity	X		KEEP AN EYE: 1) "BELT" FALLS OFF; 2) CABLES BREAK
Exhibit #41	activity		X	... LITE BULB? ADD GRAPHIC ...
Exhibit #40	computer	X		KEEP IN EYES VISITORS CHANGE SETTINGS
Exhibit #37	activity		X	GRAPHIC: CLEAR OVERLAY MISSING LEFT LOWER CORNER
Exhibit #38	activity	X		MUST RESET ... FREQUENTLY
Exhibit #55	computer	X		ADD GRAPHICS ...
Exhibit #36	activity	X		
Exhibit #34/35	activity		X	... [PARTS] NEED REPLACING
Exhibit #29	activity	X		
Exhibit #27	activity		X	1) MISSING HANDLE; 2) RUBBER TOP = "WAVY"
Exhibit #28	activity	X		A LITE STAYS ON

Table 21. Maintenance Survey 4MS

Gallery #1

Date: Day 2
Survey: 4MS

Exhibit Name	Type	Status		Nature of the Problem
		OK	N.R.	
Right Wall Activities				
Exhibit #3	live animals	X		
Exhibit #56	graphic	X		
Exhibit #4	activity	X		
Exhibit #6	graphic	X		
Exhibit #12	activity	X		
Exhibit #13	activity	N/A		NOT ON THE MAINTENANCE SHEETS BUT INCLUDED ON 3MS SURVEY
Exhibit #14	activity	X		
Exhibit #15	activity	X		
Exhibit #16	video & graphic	X		
Exhibit #19/20	activity	X		
Back Wall Activities				
Exhibit #21	computer	X		
Exhibit #23	demonstration unit	X		
Exhibit #24	video	N/A		NOT ON THE MAINTENANCE SHEETS BUT INCLUDED ON 3MS SURVEY
Middle Activity Area- Near Exhibition Entrance				
Exhibit #50	activity	X		
Exhibit #53	graphic	X		
Exhibit #52	computer	X		
Exhibit #51	activity	N/A		NOT ON THE MAINTENANCE SHEETS BUT INCLUDED ON 3MS SURVEY
Exhibit #7	activity	X		
Exhibit #8	activity	X		

Exhibit #49	activity	X		
Exhibit #48	activity	X		
Exhibit #47	activity	X		
Exhibit #11	activity	X		
Exhibit #45	activity	X		
Exhibit #44	activity	X		
Exhibit #46	activity	X		
Middle Activity Area- In the Back of the Exhibition				
Exhibit #39	activity	N/A		NOT ON THE MAINTENANCE SHEETS BUT INCLUDED ON 3MS SURVEY
Exhibit #41	activity	X		
Exhibit #40	computer	X		
Exhibit #37	activity	N/A		NOT ON THE MAINTENANCE SHEETS BUT INCLUDED ON 3MS SURVEY
Exhibit #38	activity	X		
Exhibit #55	computer	X		
Exhibit #36	activity	X		
Exhibit #34/35	activity	X		
Exhibit #29	activity	X		
Exhibit #27	activity	X		
Exhibit #28	activity	X		
NOTE				CRACKED PLEXIGLASS...

Table 22. Discrepancies between Visitor, Fenway, and Maintenance Surveys

Reason for Discrepancy	Number of Times Discrepancy Occurred on Surveys	Percent of Times Discrepancy Occurred on Surveys
Visitors noticed something maintenance didn't		
Experience didn't match visitor expectation	12	20%
Maintenance didn't check for bugs or content	9	15%
Broke between exhibit checks	5	8%
Maintenance didn't check static object cases	2	3%
Don't understand visitor comment	1	2%
Visitor couldn't find exhibit so marked broken	1	2%
Total	30	51%
Maintenance noticed something visitors didn't		
Visitors didn't notice this	12	20%
Broke after visitors went through	4	7%
Maintenance worker thought this was a different exhibit	1	2%
Total	17	29%
Both noticed the problem		
Non-functional	6	10%
Obviously broken	2	3%
Chronically broken	2	3%
Maintenance and visitor noticed different problems	2	3%
Total	12	20%

There were three factors that continually came up when visitors called something broken which maintenance did not call broken. The most common cause of this discrepancy was that the problem was deep within the program, and it could only be discovered through prolonged interaction. This was most often observed when visitors used computer exhibits such as the “SETI” program and “The Talking Map” in *Messages* or headphones such as the “Fossil Fern” in *Investigate!* (see Tables 22, 23, and 24).

Another common problem was that the exhibit was working, but the visitor’s expectations of the exhibit were not being met. A good example of this problem is the “Messages Web Site/6 Degrees of Separation” computer in *Messages*. A Museum member called this exhibit broken because there was “no sound [coming out of the speakers]. Also, [the] display requires awkward scrolling. Needs higher resolution like 1024x768” (Survey #26S). The exhibit worked, but the member did not like how it worked, and he thought it should be fixed. Another example of this issue is the “Pulley Pit Station” in *Investigate!* Fenway High School students found that they had a hard time getting this exhibit to work because it had a tendency to get stuck on the track and would

not slide down it easily. For this reason, they said the exhibit was broken or only half worked.

When maintenance called something broken but visitors did not, there was really only one reason: maintenance was focusing on a part of the exhibit that the visitors did not. One example of this was the “Hobo Flip Panels” in *Messages*. A maintenance worker noticed that the graphics on was of the panels was ripped and needed to be replaced. This detail was not something that any of the visitors, who took the surveys, noticed. That maintenance would notice something that visitors did not was also a frequent discrepancy in the *Investigate!* gallery. Maintenance workers are aware that the lights and computer components of the “Galileo Drop Stop” frequently break down. Visitors did not mention the lights on their surveys, yet they did notice the error on the computer screen. “Make a Mobile” in *Investigate!* is another example. One maintenance worker found that the switch operates in a direction opposite of what it is supposed to. No visitors noticed this or any other similar problems.

Finally, there were certain things that both visitors and maintenance workers called broken. This was most likely to occur if the exhibit was non-functional, obviously broken, or chronically broken. An example of this is the Solar Race Track in “Investigate!” During the period when the Fenway students filled out there surveys there were no cars available in the solar car area, and there were broken exhibit signs placed on the track. It is obvious to both maintenance workers and visitors that an exhibit is broken if no pieces are available. Additionally, this exhibit is chronically broken, so the Maintenance Department knows they need to keep an eye on it even if parts are available. This is also the case for the “Survey Survey” in *Investigate!* This computer is known to have bugs and frequently works incorrectly. Therefore, it is not surprising that the Maintenance Department called it broken on one of the maintenance survey days.

The two tables below list the exhibits found in *Messages* and *Investigate!* They illustrate what maintenance, visitors, and Fenway students found to be broken, what the problem was, and the reason for any discrepancy or agreement between maintenance and visitors. These two exhibits were chosen because they represent the broad cross-section of problems found in the four surveyed exhibits. To see results for *Making Models* and *Seeing the Unseen* look in Appendix H.

Table 23. Messages Exhibits Identified as Broken on Surveys

Messages	Maintenance Workers (N = 4)	Visitors/ Members (N = 4)	Fenway Students (N = 5)	Problem	Reason for Discrepancy
The Talking Map	0	1	2	Incorrect information; works inconsistently	Maintenance didn't record problems with bugs or content
Intro Corridor (1 video & 4 sounds)	0	1	0	Sound of first and last cone should be louder	Experience did not match visitor expectation
Design A Sign (Velcro board)	0	1	0	Not enough letters to make a creative sign	Experience did not match visitor expectation
Listening To Languages / Kissing Cousins	0	0	0		
Language to Go - Diner	1	4	0	Doesn't come on; unresponsive	Non-functional
A Visual Language	0	0	0		
Messages Web Site / 6 Degrees of Separation	0	1	0	No sound; needs higher resolution	Experience did not match visitor expectation
SETI program	0	2	0	Very slow; messages from SETI won't come up	Maintenance didn't record problems with bugs or content
Beehive Cam	0	4	0	No response	Broke between exhibit checks
Bee Dance	0	1	0	Should have obvious "start" button	Experience did not match visitor expectation
Navajo Unbreakable Code	0	0	3	Button doesn't work	Broke between exhibit checks
Hobo Codes	0	0	0		
What's the Message (smell & audio)	0	0	3	Visual not showing	Experience did not match visitor expectation
Do Smells Sell? (4 smells)	0	0	0		
Are You Talking To Me	0	2	3	Buttons don't always work; hearphone quiet or broken	Maintenance didn't record problems with bugs or content
Watch Yourself	0	2	0	Couldn't get it to record or play back	Broke between exhibit checks
Meaning with Music	0	1	0	Numbers missing from buttons	Experience did not match visitor expectation
Get the Picture Computer	0	2	3	Won't save your collage or let you look at others' collages	Maintenance didn't record problems with bugs or content
Show or Tell (curtain & blocks)	0	0	0		
Hobo Code flip panels (7 panels)	1	0	0	Graphics need replacement	Visitors didn't notice this
Total	2	22	14		Visitors noticed more broken exhibits than Maintenance

Table 24. Investigate! Exhibits Identified as Broken on Surveys

Investigate!	Maintenance Workers (N = 5)	Fenway Students (N = 5)	Problem	Reason for Discrepancy
Idea Exchange - Who Are You	0	0		
Pulley Pit Station (2 tracks)	0	3	Difficult to use; sleds sticky	Experience did not match visitor expectation
Roll Down Station (2 tracks)	1	0	One side broken	Broke after visitors went through
Solar Race Track (2 tracks)	3	4	No cars; no connectors for wheels; out of order	Non-functional
Idea Exchange - Solar Car?	0	0		
Solar Car Workshop - Build It Stations (2 stations)	3	1	No cars; no connectors for wheels; out of order	Non-functional
Solar Cell Pit Station	1	0	No solar cars	Maintenance worker thought this was a different exhibit
Skin Sensor	1	0	Graph not showing	Broke after visitors went through
Motion Match	2	4	Graph not showing; computer not working	Non-functional
Penny Lab	0	0		
Temperature Investigation	1	0	Replace thermometer	Visitors didn't notice this
Race of Shapes	3	4	Out of order; caution tape	Non-functional
Ping Pong Probability	0	0		
Idea Exchange - What did you investigate	4	5	Computer shut down; out of order	Non-functional
Idea Exchange - Who Used This Site	0	0		
Curator Desk Stations (2 phones)	0	0		
Botany Field Station	1	0	Can't see anything	Visitors didn't notice this
Lithic Field Station	0	0		
Zoology Field Station	0	0		
What's Hidden in the Midden	0	0		
Midden Dig Site	0	0		
What's Inside (4 disks)	0	0		
Natural Wonders (objects & audio)	0	0		
Kids Table Activity with shells	0	0		
Fossil Fern (object & audio)	0	5	Hearphone broken	Maintenance didn't record problems with bugs or content
Archeology of Us	0	0		
Survey Survey	1	2	Nothing happens when press button	Chronically broken
Question Wall	0	0		
Galileo Drop Stop (2 stations)	2	0	Needs replacement parts; error on computer	Visitors didn't notice this
Make A Mobile	1	0	Switch operates in opposite direction	Visitors didn't notice this
Idea Exchange- How Do Objects Fall	0	0		
Balance Nails (3 stations)	0	0		
Balancing Toy (3 stations)	0	0		
Picnic Challenge - Snatch the Tablecloth	0	0		
Total	24	28		Maintenance and visitors found about the same amount of exhibits broken

Besides filling out surveys, visitors, Fenway students, and volunteers were asked to take part in a half hour focus group discussion. These discussions focused on the broken exhibits visitors identified in the gallery, the criteria visitors used to identify broken exhibits, and the extent to which broken exhibits negatively affected their experience in the gallery. The data were used to explore the what, how, and why of broken exhibits for visitors (see Appendix D). Additional questions were added as focus groups occurred.

Participants generally repeated the information that they reported on the surveys. However, one topic emerged during the focus groups that did not appear with equal attention in the surveys: problems with buttons and audio. Participants from Fenway High School, members, and visitors talked about problems with buttons that were a part of components. They brought up how they had to repeatedly press buttons in order to get certain exhibits to work, how sometimes buttons did not elicit a response at all, and how kids bang on the buttons which may make them more likely to break than other exhibit components. One quote about button problems concerned a computer in *Investigate!* “‘How do objects fall?’ [Computer I] had to press that button 10 times to get it to work. With hyper kids that would work, but not with other people” (Fenway High School student). Another button-related quote was about a slow response from an exhibit. “The whoopee cushion button [in *Making Models*] I pushed several times and had to hold the button down for the woman to speak” (Female, 30).

Participants also identified audio as a problem in many of the surveyed galleries. These issues seemed to be especially problematic in *Messages* and *Making Models*. Problems with audio focused on the headphones. They were too loud or too soft, their volume could not be controlled, and they could be staticky. Other audio problems included speakers. They were also categorized as too loud or too soft, and sometimes participants complained of sounds in the galleries interfering with each other and so making exhibits more difficult to hear. One quote concerned the use of headphones in a noisy gallery.

When we were alone in the exhibit [*Messages*], you could easily hear, but when it got busier, things were harder to hear. The hearing cups were helpful. Some of us mentioned headphones. It would be good if future exhibits had them for when

it gets busy. They would be easy to maintain. I think in one area, make sure the audio is audible. When the exhibit got too loud, I couldn't hear at all. In the audio piece especially when the exhibit got too loud. (Female, 20s)

Another comment from one of the focus group participants involved audio that was not working optimally: "The 'Mayan Pyramid' the audio was very loud—some were staticky [in *Making Models*]" (Female, 20s). This problem becomes amplified for persons with disabilities who rely solely on audio to receive content (Reich, 2005).

Among the kinds of problems identified on visitor surveys, bugs or design problems were commonly mentioned. Participants complained that the workings of some of the computers were not intuitive, that programs did not work the way that they should, or that they were frozen. One such problem from the surveys concerned a non-functional computer. "One [computer] didn't work. They're frozen" (Fenway High School student). Another issue brought up during focus groups concerned computers that were slow because of their age or had poor design. "I understand they're older computers ['6 degrees of separation' computer in *Messages*], but [the interactions] need to be spontaneous. The resolution needs to be set higher, so you don't have to scroll [horizontally]. You can read three-quarters of a sentence and then you have to scroll further. [You] can get the equipment for \$3 on eBay" (Male, 40s). "No fun to go up to stuff that's slow. If it's 1990s technology, it's got to go. Right into the Charles. It's fine if it's fast, but 1 person in 1800 is going to wait" (Male, 40s in *Messages*). Other computer concerns involved bugs within the program. "['Get the Picture' computer in *Messages*] can't save your collage or look at other's collages" (Female, 20s).

Other design problems involved activities. People complained that certain designs did not work well. One of the interpretation volunteers expressed his frustration with the solar car exhibit. "Those cars have never worked—the solar cars [in *Investigate!*]. The rubber band always comes off, never works. It is subject to so much abuse, kids just push them" (Male interpretation volunteer). Other remarks involved activities that were hard to use or did not work the way the directions said they should. "Right out here you can measure your hearing [in *Seeing the Unseen*]. It doesn't go to a low or high enough frequency" (Male interpretation volunteer), and "with the smells I had troubles, they were hard to distinguish" (Female, 20s in *Messages*).

These examples illustrate the types of problems commonly discussed by participants during focus groups. This list is not complete, but it is meant to give a feeling for the range of issues brought up by participants most frequently. In order to see complete list of what was discussed, go to Appendix I.

DISCUSSION

This study gave the Museum of Science, Boston a chance to look at maintenance issues through the eyes of the visitors instead of through the lens of the Maintenance Department. Through the data, five issues emerged which need to be solved in order to make the museum experience better for visitors. The issues involve both the maintenance and design of exhibits, and solutions can only be achieved through the work and cooperation of departments across the Museum.

Issue #1: Maintenance workers are inconsistent in the determination and reporting of broken exhibits in the Museum.

Solution: Create guidelines governing the determination of broken exhibits. Also, design a new maintenance-reporting tool that allows for consistency across workers.

Issue #2: Maintenance is looking at the problem of broken exhibits differently than visitors.

Solution: Change Exhibit Operations' repair priorities to be more in line with those of the visitor. The order of priorities should be:

- Non-functioning exhibits—fix them quickly, remove them from the Museum floor, or place a sign on them;
- Partially functional exhibits—audio components, buttons, and computers—check exhibits thoroughly for problems deep within the exhibits;
- Exhibits with mechanical and cosmetic problems, which do not affect exhibit function.

Issue #3: Design choices sometimes lead visitors to think that an exhibit is broken.

Solution: Continue prototyping of all exhibits before they are placed on the Museum floor, and set aside time and money to improve faulty components as identified during remedial and summative evaluation.

Issue #4: Visitors are more frustrated with older galleries because of the preponderance of maintenance issues found there including higher numbers of exhibits that are non-functional or have chronic problems.

Solution: Replace older exhibits more often, or design them so that they can be easily removed from the Museum floor if they become chronically broken. Add broken exhibit signs to exhibits in a location that is noticeable to visitors or remove exhibits from the floor if they are non-functional or chronically broken.

Issue #5: Visitors have problems with computer-based exhibits because they become non-functional or develop internal bugs.

Solution: Special attention needs to be paid to computer components before and after they are placed on the Museum floor.

- Complete more rigorous quality assurance testing of computer-based exhibits before they are placed on the Museum floor.
- Interact with all aspects of computer programs when testing them for maintenance issues.
- Keep more detailed records about how computers crash so that problems and repairs can be easily identified.

Issue #1: Maintenance workers are inconsistent in the determination and reporting of broken exhibits in the Museum.

The data show that maintenance workers did not agree about what criteria made an exhibit broken or how to report the problem. There are two examples of how maintenance workers varied in what they called broken from day-to-day. In one of the galleries, one maintenance worker reported that eight exhibits needed remediation while the very next day a worker found no problems. It is known that not all of these issues were addressed in one day. Similarly, in another gallery, one worker said that an exhibit was fine while just the next day a maintenance worker observed that an object was missing. At the same time, evaluators were aware that the object had been missing for some time. These differences indicate that maintenance workers are not using the same criteria to discover the maintenance issues in a gallery.

Besides day-to-day differences, maintenance workers did not consistently report continuing maintenance issues. The solar car area in *Investigate!* is frequently broken yet maintenance workers describe the problem in different ways. One says, “no connectors for wheels” (Survey #17MS). Another says, “no solar cars” (Survey #18MS), and yet another describes the problem as, “solar cars are broken” (Survey #21MS). In addition, another worker indicated that the exhibit was fine on his maintenance survey. If workers are inconsistent in reporting problems with broken exhibits, then the Exhibit Operations cannot be held responsible for knowing what problems exist or how they need to be repaired.

In addition, it becomes evident from looking over the maintenance surveys that certain maintenance workers focus on issues that others ignore. Some workers mention that signs and other graphics are in need of remediation, but most workers do not. Also, some workers describe design flaws such as the fact that the “Hearing Range” exhibit in *Seeing the Unseen* needed an increased sound range to work properly; however, most workers do not talk about these kinds of exhibit issues. The Maintenance Department needs to give workers explicit instructions about what problems they need to look out for in the galleries. A list of common concerns for each gallery should be made available for workers to consult.

All this evidence illustrates that maintenance workers are not internally consistent in what they are calling broken. Certain maintenance workers are focusing on problems that others are not, and they are not consistently reporting known problems. The result is that across surveys it is not possible to be sure if an exhibit has just become broken, has been broken for some time, or has been fixed. Overall, these problems lead the Maintenance Department to think uptimes are higher than they really are.

Some of these maintenance workers were very meticulous, and others were not. The problem for the Maintenance Department is to determine which of these two types of workers is correct: the ultra-critical maintenance worker or the lenient maintenance worker. When the evaluator was trained to detect broken exhibits for this study, someone more like the ultra-critical maintenance worker taught her the maintenance protocol: any maintenance problem, big or small, leading to partial function or non-function, caused the evaluator to call an exhibit broken. The Maintenance Department may determine that these criteria are too stringent, and that only more catastrophic problems should be reported daily while other problems such as partially functional exhibits, aesthetic and design flaws should only be reported weekly or bi-monthly. Still, optimally, maintenance workers should fall closer to the ultra-critical maintenance worker than a lenient worker so that as many potential maintenance issues are identified as possible. Even though this may lead to a backlog of maintenance jobs, it is better to be aware of maintenance issues, which may get worse over time, than be surprised when an exhibit becomes completely non-functional.

In order to be able to effectively deal with maintenance issues, it is important for the Maintenance Department to create tools that will allow maintenance workers to become consistent in what they report and how they report it. For this to come to fruition three things need to happen: the Maintenance Department needs to create a list, for each gallery, of common problems that workers should be aware of; they need to create guidelines for determining if an exhibit is broken; and they need to create a new maintenance survey. In addition, each worker should be carefully trained before they are allowed to complete any maintenance surveys on their own.

Issue #2: Maintenance is looking at the problem of broken exhibits differently than visitors.

Comparing data collected from visitors to data collected from maintenance workers, it becomes evident that the two groups are focusing on different maintenance issues. Both groups are good at finding and reporting exhibits with no function. Nevertheless, visitors are more likely to call exhibits that are partially functional or have design problems broken while maintenance workers are more likely to report cosmetic or mechanical problems.

Depending on the data collection instrument, visitors called partially functioning exhibits broken while maintenance did not. Most visitors, who participated in the exit interviews, only reported non-functional exhibits broken; however, visitors, Museum members, and volunteers, who took part in the surveys and focus groups, identified exhibits with broken audio, sticky buttons, and computer bugs as broken. When visitors had a chance to interact with an exhibit more deeply and completely, they were more likely to discover problems that did not allow complete interaction with an exhibit.

Participants who took part in the visitor surveys and focus groups were encouraged to use the exhibits completely, so they were likely to use and test the audio while many exit interview visitors did not seem to interact with this aspect of the exhibits. As a result, only once did a visitor mention a broken hearphone on an exit interview. However, on the visitor surveys and focus groups, participants mentioned many audio problems such as “[I] can't hear anything through the hearphone, even after pressing the button” (Survey #25S), “audio volume slightly high” (Survey #31S), and “text is very staticky and hard to hear” (Survey #29S), which indicates that when visitors use the audio they often discover maintenance problems. Though many Museum visitors may not use this part of an exhibit, it is important to keep the audio working for those who are blind or who have disabilities that make reading difficult. Nevertheless, it appears that maintenance rarely checked the audio and hearphone components because they are never mentioned on the maintenance surveys. In order to improve the visitor experience, it is important to spend more time maintaining the audio components.

Participants in the focus groups were also more likely to mention problems with buttons than both the maintenance workers and visitors from exit interviews. One

Fenway High School student said that one of the computers worked, “but it takes long to respond. Have to push button more than once” (Survey #8S). On many of the visitor surveys, this slow response of buttons was a recurring theme. “Listened to all 8 audios - some buttons you just have to push 2 or 3 times” (Survey #30S). “Play button only sometimes works” (Survey #4S). As with the audio, the problem of sticky or slow buttons was not mentioned on exit interviews. The exit interview visitors only mentioned buttons when describing exhibits that had no function. In addition, maintenance workers did not mention slow or sticky buttons on their maintenance surveys. Slow or sticky buttons are a problem for the Museum because of the reasons stated by Jim Oker in his paper. As he explains, “A poor interface will be perceived as a broken program. It will invite your visitors to bang on your touchscreens, to try to wrench your joysticks out of the countertop” or bang on your buttons until they are broken (Oker, 1992, p.167). Because visitors may get frustrated with these slow buttons, it is important that the Maintenance Department start paying attention to them.

Finally, computer bugs were frequently mentioned on visitor surveys as creating a problem for participants, but these problems were rarely described on maintenance surveys. The bugs ranged from slow computers to computers not responding correctly to commands. In *Seeing the Unseen*, some Fenway students noticed that a computer-based video was “not playing. Says it's [sic] still loading” (Survey #20S). Similar problems also involved the computers not working at all. “Messages don't come up (within 5 minutes)” (Survey #25S). Sometimes the computer program provided incorrect information. “Upper right ‘area not open to the public’ [audio] does not work consistently, nor does ‘steps to Electric theatre’” (Survey #26S). Not all visitors may notice these problems, or they may move onto another exhibit if the problems occur. Nevertheless, it can be seen that these problems will be discovered by and bother some visitors. Maintenance occasionally reports these issues as when a worker noticed that “nothing happens when pressing a button [on the ‘Survey Survey’ computer]” (Survey #17MS). Still, comments about computer bugs were rare. Because of the concerns of visitors, computer bug remediation needs to be a higher priority for maintenance.

While visitors found problems that created partially functional exhibits, maintenance workers focused more on the mechanics and cosmetic look of exhibits. On

maintenance surveys, reports of cosmetic problems include the “Leonardo’s Window” “needs 2 pair new feet” (Survey #3MS), ripped “graphics” in *Messages* (Survey #7MS), or the “Urban Mystery Theater” “needs some cosmetic repair” (Survey #27MS). Visitors never reported that any of these issues made an exhibit “broken” even though evaluators know that some of these problems were present throughout data collection. Mechanical problems seen on maintenance surveys include “switch operates in oppiste [sic] direction” (Survey #20MS), “Heart of the Question” “sticking” (Survey #23MS), and a “light out” on the “Shape is Key” exhibit (Survey #15MS). Since these problems are not as important to visitor perceptions, they do not need to be as high a priority for maintenance as long as the exhibit still has function and the visitor will be safe when using the exhibit.

The data illustrate that Maintenance concerns are not in line with visitor concerns. In order to rectify this problem, the Maintenance Department needs to modify their remediation priorities. Most important to both visitors and maintenance is non-functional exhibits, so these problems should be dealt with first. These exhibits need to be fixed, have a broken exhibit sign placed on them, or be removed from the floor. After these issues, problems with partially functional exhibits should be addressed. Audio components, buttons, and computers should be checked thoroughly on a bi-weekly or monthly basis. These components need to be tested completely so that problems deep within the exhibit components can be found. Monthly, small mechanical or cosmetic issues that do not affect exhibit function should be checked for and repaired. Finally, the Exhibit Operations Department needs to decide if they need to check for design issues, as described below, or if this is something that should be dealt with by the Exhibits Department.

Issue #3: Design choices sometimes lead visitors to think that an exhibit is broken.

Besides finding problems that made exhibits partially functional, many visitors said that certain design issues made an exhibit broken. The relatively low percentage of visitors who reported broken design reflects the Museum's commitment to usability testing and formative evaluation of exhibit prototypes. Still, this "broken" design was seen across data collection instruments. However, as this is a design and not a maintenance issue, it was unusual to find these problems described on maintenance surveys. Design issues that caused visitors to call exhibits broken included incorrect or missing information on labels, and difficult to use or understand activities.

On comment cards, one of the main "maintenance" complaints was that information found on labels was incorrect. One visitor, who complained that information presented on a nuclear energy exhibit was inaccurate, summarizes visitor issues with label copy.

At my recent visit I was surprised to see a statement about the safety of nuclear reactors in your "new exhibits" area. This statement said something to the effect that if the cooling system in a reactor malfunctioned, a "meltdown" could occur. While it is true in a "graphite" moderated reactor (as in the Chernobyl reactor), these reactors are not the design used in US or any other western reactor, and I believe are no longer being built anywhere. In a modern, heavy-water moderated reactor, the coolant medium and the moderator are the same. If the reactor begins to overheat, the coolant boils off (possibly with some steam escape) and the reaction shuts down. No meltdown occurs. It seems especially important in our current days of \$60 a barrel oil to be very careful when presenting the safety factors of an energy source that is arguably safer per kilowatt hour than any other. Wind and water are not going to solve this very pressing problem. If you could clarify the statement and identify its source, that would be great.

(From June 16 – 30, 2005)

The Exhibits Department needs to check all their label copy, but they also need to be aware that some visitors may disagree with their labels. In addition, this complaint

illustrates that as research and technology changes, it may be important to modify labels to reflect new information.

Visitors also commonly complained that information was missing from exhibits. These visitors asked for more labels on exhibits. Examples of this kind of complaint include: “The Natural Mysteries Room has beautiful cats up above. Please identify them. There were several families, along with me, that didn't know whether we were looking at a cheetah, leopard, panther, etc...Thanks” (From May 16 – 31, 2005). Another complaint concerned the bird cases in *A Bird's World*. “There should be labels for the birds in the exhibit cases. It is frustrating when my kids asked what the birds are but I don't know and there is no way to find out. Why aren't they labeled?” (From February 1 – 15, 2005). Designers made a conscious decision not to label these objects. Still, it is important for visitors to understand why this decision was made, and they need to be able to easily find the supplemental cards, if they are available, that contain the information.

Design issues did not only concern labels but also addressed problems with the activities themselves. Difficult to use exhibits, like the ones studied by Josh Gutwill at the Exploratorium, were called broken by some visitors. This type of problem was most often mentioned on visitor surveys though it was also mentioned on a few exit interviews. In Gutwill's study, what he called “challenging” exhibits were exhibits that were functioning but that visitors could not operate. In this study, difficult to use exhibits are exhibits that visitors have a hard time operating. One exhibit that the Fenway High School students had a hard time operating was the “Pulley Pit Station” in *Investigate!* One student said, “The ‘Pulley Pit Station’ was insufficient. The audio worked, but the [pulley] car didn't. It would go up but not down” (From September 20, 2005 Group #1). She was referring to the fact that she had a hard time making the exhibit work correctly. The “sled” did not easily slide down the plane. A male visitor in the gallery also described having problems with this exhibit. “Pulley - Turn it and it seems to be off track. It's a struggle to get it to work” (Interview #110). As a result of these problems, the exhibits were not only “challenging,” but they were called broken.

Activity design issues also involved a number of exhibits where the expected result was unclear. A prime example of this kind of problem can be seen in *Seeing the Unseen*. Many visitors had problems understanding the “Piano Strobe” exhibit in the

gallery. One visitor commented, “[I] didn't know if it was working because the lights didn't seem too bright on it” (Interview #13). Another visitor responded in the same way about the exhibit. “Strobe frequency wasn't right, maybe I didn't understand it, maybe it was me” (Interview #18). The data illustrate that design can make exhibits broken for visitors.

The “Piano Strobe” example illustrates how important it is to improve or modify exhibits based on information received from visitors. In 1992, a summative evaluation of *Seeing the Unseen* was completed. In that report, evaluators found that “very few [visitors] operated the apparatus as intended and understood the connection between the beam of light and the movement of the strings” (Hein & Cohen, 1992, p. 17). As evidenced from the visitor quotes above, these misunderstandings occurred again during this study. The “Piano Strobe” was never changed as a result of the first evaluation, and during this second evaluation, visitors still did not understand the purpose or goals of the exhibit. If the “Piano Strobe” had been modified, visitors might learn from it instead of being frustrated and confused by it. This demonstrates that it is important to change and modify problematic exhibit design based on information from evaluations.

The data generated through this study illustrate that design choices can be a major hindrance to visitor use of an exhibit. Poor interface and suboptimal materials can make an activity difficult to use and frustrate visitors. In addition, label copy can also be a problem for visitors. Changing information or “missing” labels can cause visitors to become aggravated with the museum experience. Label copy is especially important on static exhibits since visitors will pay more attention to the labels on these pieces. Continuing usability testing is critical to ensure that as many design issues and visitor concerns as possible are solved before exhibits reach the Museum floor. In addition, it is important for the Exhibits Department to set aside money and time so that they can modify and improve exhibits as concerns arise from either remedial or summative evaluation reports or the Exhibit Operations Department.

Issue #4: Visitors are more frustrated with older galleries because of the preponderance of maintenance issues found there including higher numbers of exhibits that are non-functional or have chronic problems.

As exhibits age, it makes sense that they will have more maintenance problems. This study has confirmed that this speculation is true at the Museum of Science. Visitors had many more complaints about two of the older galleries (*Investigate!* and *Messages*) than two of the younger galleries (*Making Models* and *Natural Mysteries*). The only exception was *Seeing the Unseen*, which is the oldest gallery in the study, but closer examination of the design of this gallery explains why this discrepancy occurred.

The galleries in this study ranged in age from two to fifteen years old at the time the study was completed. *Seeing the Unseen* was created in 1991, so it was the oldest gallery. *Investigate!* was about nine years old since it was finished in 1996. *Messages*, which opened in 1999 was about six years old. *Natural Mysteries* was created in 2000, so it was about five years old. Finally, *Making Models / Mapping the World Around Us* was the newest gallery having been completed in 2003. It was two years old at the time of the study.

Overall, more maintenance issues were found in *Investigate!* and *Messages* than the other galleries. More visitors found broken exhibits in those two galleries: 64% in *Investigate!* and 48% in *Messages*. Visitors also generally reported finding more broken exhibits in the older galleries. This is especially true in *Investigate!* where visitors on exit interviews reported up to seven broken exhibits. In all the other galleries, the maximum number of broken exhibits reported was two or three.

In the two newer galleries, both evaluators and visitors found fewer problems. The average downtime in both *Making Models / Mapping the World Around Us* and *Natural Mysteries* was about 14%. In addition, only 36% of visitors to *Natural Mysteries* and 24% of visitors to *Making Models / Mapping the World Around Us* reported encountering broken exhibits. They also found fewer broken exhibits. The maximum number of broken exhibits reported by any single visitor in the two galleries was three.

Besides reporting more maintenance issues, visitors were more disappointed in *Investigate!* and *Messages* and enjoyed them less than the other galleries. In *Investigate!*, 55% of visitors rated their disappointment in the gallery a five or higher on a ten-point

scale. In addition, *Investigate!* was the only gallery that any visitors ranked below a five in enjoyment. In *Messages*, visitors were more disappointed than they were in *Natural Mysteries* or *Making Models / Mapping the World Around Us*. Sixteen percent of visitors ranked *Messages* five or higher on a ten-point scale of disappointment of the number of broken exhibits. Visitors also ranked *Messages* lower on the enjoyment scale; 52% of visitors ranked the gallery a seven or lower.

Disappointment was not as high and enjoyment was not as low in the newer galleries: *Making Models / Mapping the World Around Us* and *Natural Mysteries*. No one ranked their disappointment in the number of broken exhibits in these galleries higher than a five, and the number of visitors who ranked their disappointment a five was low. Only 4% of visitors to *Natural Mysteries* and 8% of visitors to *Making Models / Mapping the World Around Us* ranked the galleries a five. In addition, fewer people ranked their enjoyment in the galleries seven or below. Forty percent of visitors to *Natural Mysteries*, and 36% of visitors to *Making Models / Mapping the World Around Us* ranked the galleries on this end of the scale.

Seeing the Unseen, on the other hand, breaks many of these age trends. This gallery tends to fall between the older (*Investigate!* and *Messages*) and younger (*Making Models / Mapping the World Around Us* and *Natural Mysteries*) galleries on the scales discussed above despite the fact that it was the oldest gallery in this study. Evaluators found the fewest broken exhibits in this gallery (average downtime 10%). Forty-eight percent of visitors reported broken exhibits, which is the same as *Messages*. The maximum number of exhibits called broken was two, which is lower than any of the other galleries. Twenty-four percent of visitors ranked their disappointment in the number of broken exhibits five or more. This is more than *Messages* but less than *Investigate!* Finally, 40% of visitors ranked their enjoyment in the gallery a seven or below. This is the same as *Natural Mysteries*.

Three factors about *Seeing the Unseen* contributed to the gallery having fewer maintenance problems than other old galleries. First of all, the Maintenance Department removed many of the troublesome exhibits out of the gallery. The Exhibit Operations Manager disclosed that many non-functioning and chronically broken exhibits were permanently removed from the gallery. Secondly, one of the meticulous maintenance

workers took care of this gallery. He or she was careful to report every known or potential problem on their survey. Finally, fewer non-functional exhibits were found in this gallery than the older galleries. Over the course of the study, evaluators called only 9% of the exhibits in *Seeing the Unseen* non-functional. The numbers jump for the other old galleries. Twenty-two percent of the exhibits in *Investigate!* were non-functional at one time or another, and 19% of the exhibits in *Messages* were non-functional. By contrast, only 5% of the exhibits in *Making Models / Mapping the World Around Us* and 4% of the exhibits in *Natural Mysteries* were ever non-functional.

The solution to the age problem involves changing both design and maintenance practices. Optimally, exhibits should be designed so that they can be removed from the floor if they become non-functional or have continual problems, a solution that was suggested by Sue Wageman during her “Everything is Broken” talk. This way they can be worked on away from the viewing public, who will not even know what they are missing. Another way that the Exhibits Department could alleviate this problem is to rotate exhibitions more often. As evidenced in this section, if the exhibits were newer, then visitors would not be bothered with as many maintenance issues.

The Exhibit Operations Department also needs to change their practices. Any exhibit that is non-functional should be repaired as quickly as possible. If the exhibit needs to be repaired on the floor, then a broken exhibit sign should be placed on it in a location that is easily noticed by visitors. If the exhibit frequently has problems, or if it is going to take a long time to repair, then it should be taken off the floor to be fixed. The idea is that it is better for an exhibit to be missing than it is for a visitor to become frustrated with a non-functioning exhibit.

Issue #5: Visitors have problems with computer-based exhibits because they become non-functional or develop internal bugs.

Computer-based exhibits caused many more problems for visitors than other types of exhibits. One-third of the maintenance issues described by visitors on exit interviews involved computers. In general, the problems described on exit interviews and comment cards described non-functioning computers, but on the visitor surveys and during focus groups, problems with internal computer bugs also became apparent.

During the course of the study, it became clear that many of the computers in the galleries had maintenance issues. Evaluators found that between 0% and 45% of computers in the galleries were non-functional, and that between 0% and 45% of computers in the galleries were partially functional. However, only one of the galleries had no computer problems, and the other four galleries had some kind of problem with at least 57% of their computers during the course of the study. With such a high number of computer issues, computers exhibits are becoming a liability in galleries.

Similarly, on exit interviews, between 0% and 29% of the computers in the galleries were called broken by visitors at some point. Many of these comments focused on non-functional computers. Visitors made comments like: “[I] noticed [the] computer [was] frozen” (Interview #64), “the computer didn't turn on” (Interview #124), or “[the] buttons did not work” (Interview #78) when they described non-functional interfaces. However, occasionally visitors described computer bugs on exit interviews. These comments consisted of thoughts like: there were “folders on [the] screen” (Interview #135), or “it's not responding to buttons being pushed” (Interview #110). Despite these comments, it was very rare that visitors would notice and describe computer bugs

On visitor surveys, comments about computer bugs were much more common. During the surveys, visitors were encouraged to explore all aspects of an exhibit thoroughly, so they had a deeper experience with many of the exhibits than most visitors normally do. Evaluators compared the visitor surveys and maintenance surveys and found that visitors discovered internal bugs in nine computers while maintenance workers never reported these problems.

Through their interactions with computers, visitors reported on their surveys that they discovered computers that were dispensing incorrect information, that were working

very slowly, or that were only partially working. Comments about computers supplying incorrect information focus on “The Talking Map” computer in *Messages*. Examples of comments concerning this exhibit include: “some places are wrong info” (Survey #4S), “false info” (Survey #3S), and “upper right ‘area not open to the public’ does not work consistently, nor does ‘steps to Electric theatre’” (Survey #26S). Another problem was slow-working computers. A computer in *Messages*, the “SETI computer,” was working so slowly that one participant did not get a response “within 5 minutes” (Survey #25S). In *Investigate!*, some visitors had a similar complaint. They said the “How Do Objects Fall?” computer works, “but it takes long to respond. Have to push button more than once” (Survey #8S). Another visitor survey also mentioned problems with buttons that created a partially functional exhibit. One visitor discovered that the “up button doesn't work” on the “Where Am I?” exhibit (Survey #13S). A few other participants noticed that the computer component of “Flying Over the Atomic Landscape” was “off” (Survey #12S, 16S, 30S).

Problems with computer-based exhibits were discussed even more deeply during the focus group discussions. One interpretation volunteer noted that maintenance problems “tend to be [with] computer exhibits—need to be better tested or go around every morning to check them” (From October 20, 2005 Group). Another volunteer said, “I see a lot of notices on the screens” (From October 25, 2005 Group). While another replied, “Again, older computers get hung up” (From October 25, 2005 Group). These volunteers are around the computers all the time, and like the evaluators, they see that the computers have consistent problems.

Participants also reported many problems with individual computer exhibits. One Fenway student reported a computer bug in the *Messages* gallery, “‘Get the Picture’—only let you choose [the] make it [option] and not [the] guess [option]” (From September 20, 2005 Group #1). Another interpretation volunteer found a different bug in *Messages*, “One computer-based interactive wanted you to download something—flash” (From October 25, 2005 Group). These problems may not make a computer non-functional, but they should still be fixed.

The data demonstrate that computers are a consistent problem for visitors. When the computers are not functioning, visitors notice them. When they are functioning, there

can still be problems with broken buttons and internal bugs. Even though visitors tend not to notice these problems, they may progress to the point where computers become chronically broken or non-functional. In addition, the bugs and other issues reported here will always be a problem for some visitors. For these reasons, both the Exhibit Operations and Exhibits Departments need to change their practices. The Exhibit Operations Department needs to pay more attention to the computer exhibits. They should make sure that the computer is not only on, but that no bugs are hindering use. These bugs should be fixed if at all possible. The Exhibits Department needs to thoroughly test the computer programs before they reach the floor to try to eliminate any bugs. In order to do this, more rigorous testing quality assurance testing needs to be a part of the computer prototyping process.

CONCLUSION

The study sought to find out what maintenance issues are important to visitors by asking three questions:

1. Where is the discrepancy between visitors and maintenance workers?
2. What broken exhibit factors are visitors most frustrated with?
3. What is broken in the eyes of the visitor?

Through those three questions, it was discovered that there is a discrepancy between the number and type of broken exhibits maintenance workers and visitors report. Visitors are more frustrated in older galleries, which contain a multitude of computer-based exhibits, and visitors will most often call exhibits with no function broken, though exhibits with partial function and design issues may be called broken under certain circumstances.

Maintenance workers were found, in general, to under-report broken exhibits compared to the evaluators of this study. Compared to visitors, who submitted comment cards or filled out visitor surveys, they also under-reported broken exhibits; however, compared to visitors, who took part in exit interviews, maintenance workers reported about the same number of broken exhibits. Nevertheless, maintenance reported some problems like cosmetic issues and problems with switches and lights that visitors never noticed, and visitors reported some problems like computer bugs, broken audio, and label problems which maintenance never reported. Overall, the maintenance workers need to be more consistent in their reporting methods, and they need to pay more attention to issues like missing labels, broken audio, computer bugs, and broken buttons.

On the whole, visitors had more problems with older galleries than the newer galleries. The older galleries had higher exhibit downtimes leading to more exhibits being identified as broken by visitors and greater frustration in the number of broken exhibits. In addition, *Investigate!* and *Messages*, the galleries that caused the most problems for visitors, had a greater number of computer-based components, which also frustrated visitors. The computer-based exhibits were often broken, and visitors often identified them as broken. This was especially important in *Messages* where 67% of the exhibits identified as broken by visitors were computer-based.

Visitors have a hierarchy of what they identify as broken. First of all, they will call an exhibit broken if it has no function. Secondly, they will call some exhibits broken

if they have design issues, and finally, if they have the time to thoroughly use an exhibit, they will find problems with partially broken exhibits.

Visitors also ignore certain maintenance issues. Mechanical problems such as reversed switches and burnt out light bulbs are not important to visitors as long as the exhibit still functions. Cosmetic problems such as loose pieces, torn graphics, and worn pieces are also not important to visitors if they are not distracting.

To improve the visitor experience, the Exhibit Operations Department needs to become internally consistent in their reporting. They need to be on the same page about what makes an exhibit broken, and how to report the maintenance issues. They should first focus on non-functional exhibits and then worry about computer bugs, audio, and buttons. Finally, they can focus on mechanical and cosmetic problems. In addition, the Exhibits Department should continue to test the usability of components. They should also make sure to keep information on labels, including facts and instructions, up-to-date.

It is important to continue with this study in the future. One possible study would include targeted observations of broken components to get an idea of how visitors naturally interact with and react to broken exhibits. Also, the question of what happens on busy museum days was not answered through this study. The Research Department could collect exit interviews and gallery sweeps during school vacation weeks in order to find out if broken exhibits are more of a problem when the museum is especially crowded. It also seems that broken exhibits are disruptive to the visitors' museum experiences. It would be interesting to find out if visitors are learning less in exhibits with a lot of broken exhibits because of this disruption. Finally, the Research Department can gather baseline exit interviews from visitors as they are leaving to find out the percent of broken exhibits visitors think are in the Museum. This number can then be compared to visitors after changes to maintenance protocols are implemented in order to see the affect of the changes.

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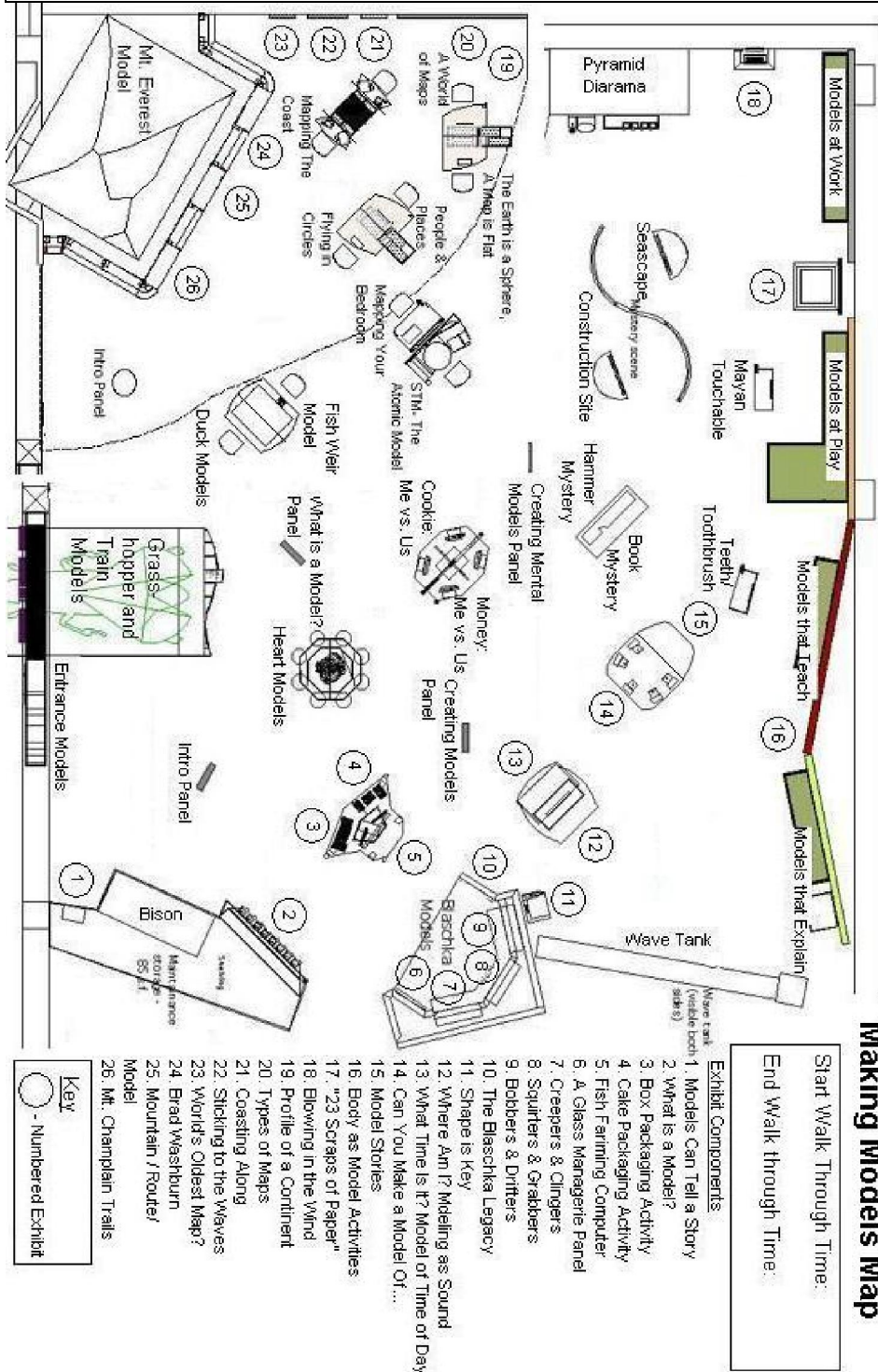
Appendix A: Making Models/Mapping the World Around Us
Timing & Tracking Map

Date: _____ **Time of Day:** _____ **Survey #:** _____ **Interviewer Initials:** _____

Visitor Gender: _____ Male _____ Female **Visitor Age:** _____

Visitor Group Type: _____ Adults _____ Kids _____ Adults and Kids

Visitor Elapsed Time: _____



Broken Components:

Making Models Map

Start Walk Through Time: _____

End Walk through Time: _____

Exhibit Components:

1. Models Can Tell a Story
2. What is a Model?
3. Box Packaging Activity
4. Cake Packaging Activity
5. Fish Farming Computer
6. A Glass Managerie Panel
7. Creepers & Grinders
8. Squitters & Grabbers
9. Bobbers & Drifters
10. The Blaschka Legacy
11. Shape is Key
12. Where Am I? Modeling as Sound
13. What Time is It? Model of Time of Day
14. Can You Make a Model Of...
15. Model Stories
16. Body as Model Activities
17. "23 Scraps of Paper"
18. Blowing in the Wind
19. Profile of a Continent
20. Types of Maps
21. Coasting Along
22. Sticking to the Waves
23. World's Oldest Map?
24. Brad Washburn
25. Mountain / Route / Model
26. Mt. Champlain Trails

Key
○ - Numbered Exhibit

Appendix A: Seeing the Unseen Timing & Tracking Map

Date: _____ **Time of Day:** _____ **Survey #:** _____ **Interviewer Initials:** _____

Visitor Gender: _____ Male _____ Female **Visitor Age:** _____

Visitor Group Type: _____ Adults _____ Kids _____ Adults and Kids

Visitor Elapsed Time: _____

Seeing the Unseen Timing and Tracking Map

Exhibition Components

- Entrance Panel
- Observatory Story: Rachel Carson
- Whose Woods Are These?
- Touch Sensitivity / Surface Roughness
- Observatory Story: George Seurat
- Where's Waldo?
- Reflecting Pond
- Bioscanner
- Observatory Story: Ernest Everett Just
- Are You As Blind As a Bat? Or Can You See Like a Bee?
- Spectra
- Hot or Cold?
- Motion Detector
- Stop the Motion
- Whirling Watcher
- It's About Time
- Observatory Story: Harold E. Edgerton
- Observatory Story: Maria Mitchell
- Piano Strings
- Piano Strobe
- Scanning Electron Microscope Panel
- Scanning Electron Microscope Computer
- Scanning Electron Microscope
- What is the Story of this Mummy?
- Mummy Case
- Observatory Story: Galileo Galilei
- BYOS- Bring Your Own Stuff Microscope
- Life in a Drop of Pondwater
- Insect- Earthly Aliens
- Seeing the Unseen: Looking at the World Beyond Your Senses
- 31 and 33. Unseen Worlds
- From Outer Space to Inner Space
- Infrared Camera
- What's at the End of a Rainbow?
- Giant Magnifying Glass
- Visible Effects of the Invisible
- Splash in a Flash
- Reverse Distance
- Disappearing Act
- Color Reversal
- ABC Picture
- Peepholes of Perception
- Smell Survey
- Vibration Sensation
- Hearing Range
- Listen Up
- Bone Stress
- Playing with Polarizing Light
- Leonardo's Window
- Dark Light
- Camouflaged Melodies
- Learning to Look
- The Observatory Panel

Start Walk Through Time: _____

End Walk Through Time: _____

Key

□ -- Activity

○ -- Text Panel

Appendix A: *Natural Mysteries* Timing & Tracking Map

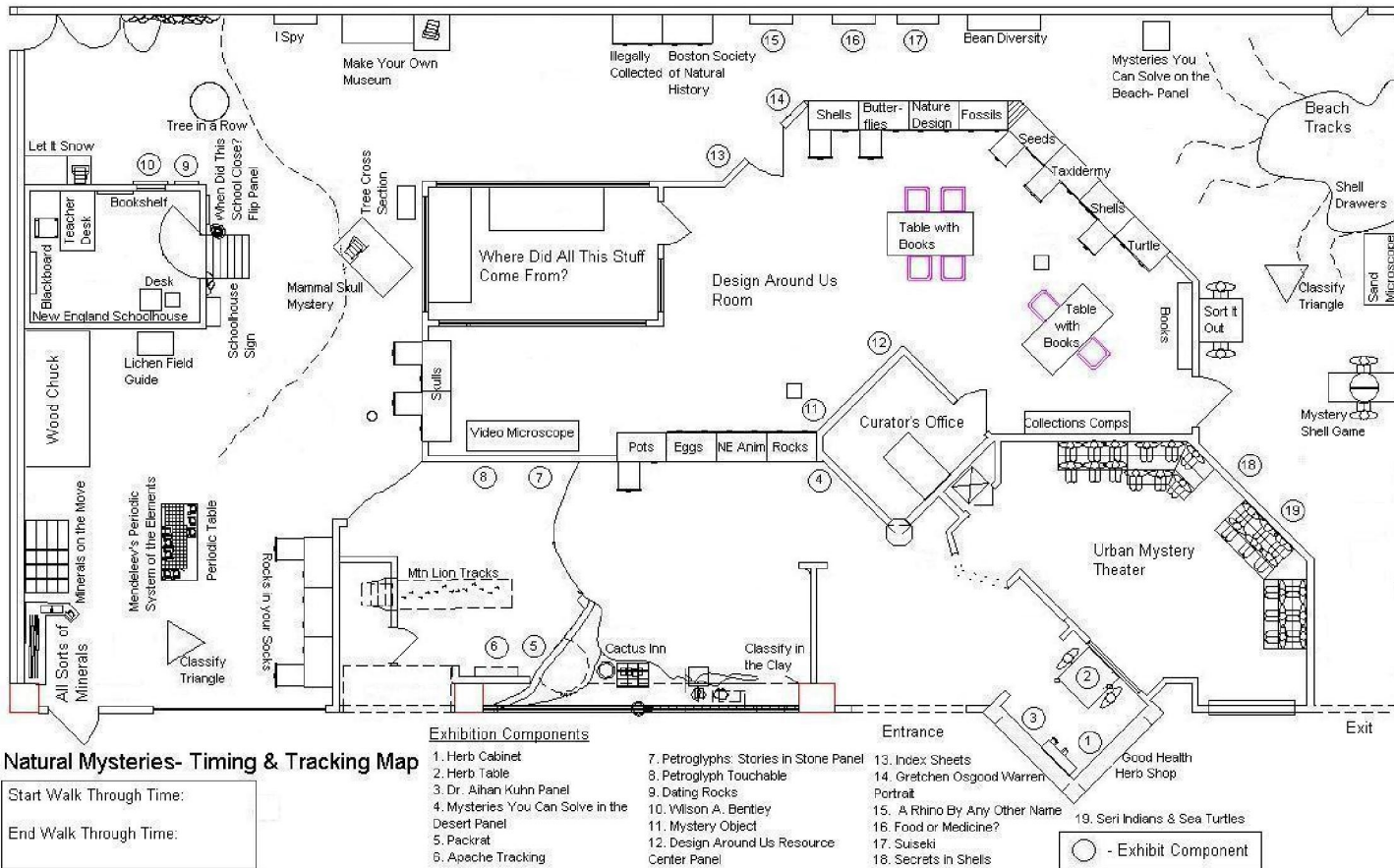
Date: _____ **Time of Day:** _____ **Survey #:** _____ **Interviewer Initials:** _____

Visitor Gender: _____ Male _____ Female **Visitor Age:** _____

Visitor Group Type: _____ Adults _____ Kids _____ Adults and Kids

Visitor Elapsed Time: _____

Broken Components:



Appendix B: Exit Interview

Exhibit Maintenance Interview

About this study:

- The Museum is looking for feedback from our visitors about the design of our exhibits to help us to create better exhibits in the future.
- The length of this interview is approximately 5 to 7 minutes.
- Only one person in the group can participate (and that is you).
- We are looking for information about the gallery you just visited. I can point out the boundaries of the exhibition if you want.
- After you fill out the questionnaire, I have a few more questions to ask you.
- Your participation is voluntary and you can opt out of the interview at any time and we will throw out your survey.

Please circle your response.

1. On a scale of 1 to 10, how would you rate your enjoyment in this gallery?

1 2 3 4 5 6 7 8 9 10
Not at all enjoyable Very enjoyable

2. How does this gallery compare to others here at the Museum of Science?

Better than Most Same as Most Worse than Most

3. How many of the exhibits you visited in this gallery were broken or not working?

0 1 2 3 4 5 6 7 8 9 10+

4. How does the number of broken exhibits in this gallery compare to other galleries in the museum?

Higher About the Same Lower

5. Please rate the following statements:

"I was disappointed in the number of broken exhibits in this gallery."

1 2 3 4 5 6 7 8 9 10
Strongly disagree Strongly agree

"I was disappointed in the number of broken exhibits in the museum."

1 2 3 4 5 6 7 8 9 10
Strongly disagree Strongly agree

About you...

Gender: Male Female Age: _____

Group Type: Adults only Kids only Adults and kids

Exhibit Maintenance Interview

Date:	Time of Day:	Survey #:	Interviewer Initials:
Exhibit:	Making Models	Natural Mysteries	
	Messages	Seeing the Unseen	
	Investigate!		

6. Would you mind describing for me some examples of activities you tried to use in this gallery that were not working?
- a. How did you determine that this activity was not working?
 - b. Do you have any other examples? (Ask this question until they name at least three activities or say they do not have any further activities they encountered)

Example 1:

Example 2:

Example 3:

Others:

7. Is there anything else you would like to add?

Thank you for your time. Enjoy your day at the Museum.

Appendix C: Investigate! Visitor Survey

Investigate!

Date: _____
 Time: _____
 Age: _____
 Gender: _____ Male _____ Female

Is the exhibit working? How did you determine that the exhibit was not working?

Exhibit Name	Type	Yes	No	How did you determine that the exhibit was not working?
Car Activity Area				
Idea Exchange - Who Are You	computer			
Pulley Pit Station (2 tracks)	activity			
Roll Down Station (2 tracks)	activity			
Solar Race Track (2 tracks)	activity			
Idea Exchange - Solar Car?	computer			
Solar Car Workshop - Build It Stations (2 stations)	activity			
Solar Cell Pit Station	activity			
Water Activity Area				
Skin Sensor	activity & computer			
Motion Match	activity & computer			
Penny Lab	activity & computer			
Temperature Investigation	activity & computer			

Appendix C: *Investigate!* Visitor Survey

Race of Shapes	activity			
Ping Pong Probability	activity			
Idea Exchange - What did you investigate	computer			
Midden Dig Activity Area				
Idea Exchange - Who Used This Site	computer			
Curator Desk Stations (2 phones)	audio			
Botany Field Station	activity			
Lithic Field Station	activity			
Zoology Field Station	activity			
What's Hidden in the Midden	computer			
Midden Dig Site	activity			
Lure of Questions Activity Area				
What's Inside (4 disks)	activity			
Natural Wonders (objects & audio)	activity			
Kids Table Activity with shells	activity			
Fossil Fern (object & audio)	activity			
Archeology of Us	activity			

Appendix C: *Investigate!* Visitor Survey

Survey Survey	computer			
Park Activity Area				
Museum Buttons	computer			
Question Wall	graphic & activity			
Galileo Drop Stop (2 stations)	activity & computer			
Make A Mobile	activity			
Idea Exchange- How Do Objects Fall	computer			
Balance Nails (3 stations)	activity			
Balancing Toy (3 stations)	activity			
Picnic Challenge - Snatch the Tablecloth	activity			

Appendix C: *Making Models* Visitor Survey

Making Models

Date: _____

Time: _____

Age: _____

Gender: _____ Male _____ Female

Exhibit Name	Type	Is the exhibit working?		How did you determine that the exhibit was not working?
		Yes	No	
Entrance Area				
Giant Grasshopper	artifact			
Honey I Shrunk the Locomotive	activity			
Helicopter Video	video			
Intro Wall Models (6 models)	artifact			
Cases Near Entrance				
Models Can Tell A Story	artifact			
Models Can Take Us Back In Time-Great Plains	audio & artifact			
What Is A Model (8 buttons/panels)	audio			
Glass Model Area				
Glass Menagerie	artifact			
Creepers & Clingers	artifact			
Squirters & Grabbers	artifact			

Appendix C: *Making Models* Visitor Survey

Bobbers & Floaters	artifact			
Blaschka Legacy	artifact			
Middle Interactive Area				
Packaging (2 stations)	activity			
Fish Farming	computer			
Heart Models (8 stations)	activity			
Me Vs Us: Take It Or Leave It	computer			
Me Vs Us: Compete Or Cooperate	computer			
What Time Is It	activity			
Where Am I	computer			
Can You Make A Model Of (5 stations)	activity			
Model Stories	computer			
Mystery Object - Book	activity			
Mystery Object - Hammer	activity			
Mystery Scene - Construction Site	activity			
Mystery Scene - Lobster Boat	activity			

Appendix C: *Making Models* Visitor Survey

Which Model Is Best?	audio & artifact			
This Is A Model Of...?	audio			
Flying Over The Atomic Landscape	activity & video			
Cases Near the Back				
Shape Is Key	audio & artifact			
Wave Tank	artifact			
Models That Explain Case	artifact			
Use Your Body as a Model	activity			
Models That Teach Case	artifact			
Models That Teach- Teeth & Toothbrush	audio & artifact			
Models At Play Case	artifact			
Models at Play- Mayan Pyramid	audio & artifact			
23 Scraps Of Paper	artifact			
Models At Work Case	artifact			
Blowing In The Wind	activity & audio			
Creating A Model - Pyramids at Giza	audio			

Appendix C: Messages Visitor Survey

Messages

Date: _____
 Time: _____
 Age: _____
 Gender: _____ Male _____ Female

Is the exhibit working? How did you determine that the exhibit was not working?

Exhibit Name	Type	Yes	No	
Entrance Area				
The Talking Map	activity			
Intro Corridor (1 video & 4 sounds)	audio & video			
Wall Activities				
Design A Sign (Velcro board)	activity			
Listening To Languages / Kissing Cousins	computer			
Language to Go - Diner	audio			
A Visual Language	video			
Messages Web Site / 6 Degrees of Separation	computer			
SETI program	computer			
Beehive Cam	computer			
Bee Dance	computer			

Appendix C: Messages Visitor Survey

Navajo Unbreakable Code	video			
Hobo Codes	audio			
What's the Message (smell & audio)	activity			
Do Smells Sell? (4 smells)	activity			
Middle Interactive Area				
Are You Talking To Me	computer			
Watch Yourself	computer			
Meaning with Music	audio & computer			
Get the Picture Computer	computer			
Get the Picture Collage Sheets	activity			
Show or Tell (curtain & blocks)	activity			
Scattered Throughout Exhibition				
Hobo Code flip panels (7 panels)	audio			

Seeing the Unseen

Date: _____
 Time: _____
 Age: _____
 Gender: _____ Male _____ Female

Is the exhibit working? How did you determine
 Yes No that the exhibit was not
 working?

Exhibit Name	Type	Yes	No	How did you determine that the exhibit was not working?
Right Wall Activities				
Observatory Story: Rachel Carson	graphic			
Whose Woods Are These?	live animals			
Henri Rousseau - The Dream, 1910	graphic			
Touch Sensitivity	activity			
Observatory Story: Georges Seurat	graphic			
Where's Waldo	graphic			
Observatory Story: Ernest E. Just	graphic			
Are You As Blind As A Bat? Or Can You See Like A Bee?	graphic			
Hot or Cold	activity			
Motion Detector	activity			
Stop the Motion	activity			

Appendix C: *Seeing the Unseen* Visitor Survey

Whirling Watcher	activity			
It's About Time	video & graphic			
Observatory Story: Harold E. Edgerton	graphic			
Observatory Story: Maria Mitchell	graphic			
Piano Strobe	activity			
Back Wall Activities				
Scanning Electron Microscope Panel	graphic			
Scanning Electron Microscope Simulation	computer			
Scanning Electron Microscope	demonstration unit			
Mummy Text Panel	graphic			
Mummy Case	artifact			
Mummy Video	video			
Observatory Story: Galileo Galilei	graphic			
Seeing the Unseen: Looking at the World Beyond Your Senses	graphic			
Left Wall Activities				
Unseen Worlds (2 panels)	graphic			
From Outer Space To Inner Space	graphic			

Appendix C: *Seeing the Unseen* Visitor Survey

The Observatory: Seeing the Unseen	graphic			
Middle Activity Area- Near Exhibition Entrance				
Leonardo's Window	activity			
Learning to Look: The Forest has Eyes	graphic			
Camouflaged Melodies	computer			
Dark Light	activity			
Reflecting Pond	activity			
Bioscanner	activity			
Playing with Polarizing Light (2 stations)	activity			
Bone Stress	activity			
Listen Up	activity			
Spectra	activity			
Vibration Sensation	activity			
Smell Survey	activity			
Hearing Range (2 stations)	activity			
Peepholes of Perception	graphic			

Appendix C: *Seeing the Unseen* Visitor Survey

ABC Animalia Pictures by Graeme Base	graphic			
Middle Activity Area- In the Back of the Exhibition				
Reverse Distance	activity			
Color Reversal	activity			
Disappearing Act	computer			
Visible Effects of Invisible	activity			
Splash in a Flash	activity			
Quick As A Wink	computer			
Giant Magnifying Glass	activity			
Infrared Camera & Light Wall	activity			
Insects - Earthly Aliens Microscope	activity			
BYOS - Bring Your Own Stuff Microscope	activity			
Life in a Drop of Pondwater Microscope	activity			

Appendix D: *Investigate!* Maintenance Survey

Component	Type	Status		Nature of Problem
		O.K.	N.R.	
Investigate				
Bells: Exploratorium Unit	interactive activity			
Idea Exchange - Who Are You	interactive computer			
Pulley Pit Station	interactive activity (2)			
Solar Race Track	interactive activity (2)			
Idea Exchange - Solar Car?	interactive computer			
Solar Car Workshop - Build It Stations	interactive activity (3)			
Solar Cell Pit Station (cell, meter, filters)	interactive activity			
Skin Sensor (computer, 4 stuff)	interactive activity computer			
Penny Lab (scale, computer)	interactive activity computer			
Motion Match (computer, sensor)	interactive activity computer			
Temperature Investigation	interactive activity computer			
Race of Shapes (Small Fish Tank)	interactive activity			
Ping Pong Probability	interactive activity			
Curator Desk Stations (2 phones, stuff)	interactive audio (2)			
Lithic Field Station (mag,specimens)	interactive activity			
Botany Field Station (wentz, spec.)	interactive activity			
Zoology Field Station (mag,specimens)	interactive activity			
Midden Dig Site (shells, matrix, tools)	interactive activity			
What's Inside (4 disks)	interactive activity			
Natural Wonders objects, audios	interactive activity			
Fossil Fern object & audio	interactive activity			
Archeology of Us (6 objects, 2 audios)	interactive activity			
Survey Survey	interactive computer			
Kids Table Activity (shells, magnifiers)	interactive activity			
Galileo Drop Stop	interactive activity (2) computer			
Make A Mobile	interactive activity			
Balance Toy (Mini Tip & Spin)	interactive activity			
Balance Nails (Counter Activities)	interactive activity (3)			
Idea Exchange Gravity /Balance	interactive computer			

Appendix D: *Investigate!* Maintenance Survey

Component	Type	Status		Nature of Problem
Investigate		O.K.	N.R.	
Question Wall	graphic			
Picnic Challenge - snatch Tablecloth activity	interactive activity			
Idea Exchange - What did you investigate	interactive computer			
Idea Exchange - Who Used This Site	interactive computer			
Roll Down Station	interactive activity			
What's Hidden in the Midden	interactive computer			

Appendix D: *Making Models* Maintenance Survey

Component	Type	Status		Nature of Problem
		O.K.	N.R.	
Making Models				
Blowing In The Wind	Interactive Activity			
Can You Make A Model Of	Interactive Activity (5)			
Fish Farming	Interactive Computer			
Flying The Atomic Landscape	Interactive Activity			
Heart of the Question	Interactive Activity (8)			
Honey I Shrunk the Locomotive	Interactive Activity			
Me Vs Us: Take It Or Leave It	Interactive Computer			
Me Vs Us: Complete Or Cooperate	Interactive Computer			
Model Stories	Interactive Computer			
Models That Teach	Interactive Audio			
Mystery Object	Interactive Activity (2)			
Mystery Scene	Interactive Activity (2)			
Packaging	Interactive Activity (2)			
Shape Is Key	Interactive Audio, Artifact			
This Is A Model Of...	Interactive Audio			
Wave Tank	Interactive Activity			
What Is A Model	Interactive Audio (8)			
What Time Is It	Interactive Activity			
Where Am I	Interactive Computer			
Which Model Is The Best	Interactive Audio			

Appendix D: Messages Maintenance Survey

Component	Type	Status		Nature of Problem
		O.K.	N.R.	
Messages		O.K.	N.R.	
A Visual Language (video)	interactive video			
Are You Talking To Me	interactive computer			
Bee Dance	interactive computer			
Beehive Camera interactive	interactive computer			
Design A Sign (velcro board)	interactive activity			
Do Smells Sell? (4 smells)	interactive activity			
Get the Picture II (computer)	interactive computer			
Hobo Code flip panels (7 w/audio)	interactive audio			
Hobo Message (audio)	interactive audio			
Intro Corridor (4 audios and video)	video & 4 audios interactive computer			
Language to Go - Diner (audio)	interactive computer			
Listening To Languages/Kissing Cousins	interactive computer (2)			
Meaning with Music (audio & computer)	interactive activity computer			
Messages Web Site /6 degrees of separation	interactive computer			
Navajo Unbreakable Code (video)	interactive video / computer			
SETI program	interactive computer			
Show or Tell (curtain & blocks)	interactive activity			
Watch Yourself (computer)	interactive computer			
What's the Message (smell & audio)	interactive activity			

Appendix D: *Natural Mysteries* Maintenance Survey

Component	Type	Status		Nature of Problem
		O.K.	N.R.	
Natural Mysteries				
Why Classify	interactive activity			
Lift To See	interactive activity			
Tradional Chinese Medicine	interactive activity			
Smell Drawers	interactive activity			
Urban Mystery Theater	interactive activity computer			
Time Traveler	interactive activity computer			
Classify in Clay	interactive computer			
Cactus Inn	interactive activity			
Apache Tracking - Wall Unit	interactive activity			
Apache Tracking	interactive activity computer			
Periodic Table	interactive activity			
Periodic Table Computer	interactive computer			
All Sorts of Minerals	interactive activity			
Minerals on the Move	interactive activity			
Woodchuck Diorama - Audio	interactive activity			
Mammal Skull Mystery	interactive computer			
Dating Rocks	interactive activity			
Let It Snow	interactive computer			
Tree In A Row	interactive activity			
Snowflake Collector - Wall Story	interactive activity			
Make Your Own Museum	interactive activity			
Resource Room Computers	interactive computer (2)			
Resource Room Optch Scope	interactive activity			
Food or Medicine - Wall Story	interactive activity			
Suiseki - Wall Story	interactive activity			
Beach Animal Tracks	interactive activity (5)			
Beach Optech Scope	interactive activity			
Sort It Out	interactive activity			
Mystery Shell	interactive activity			

Appendix D: *Natural Mysteries* Maintenance Survey

Component	Type	Status		Nature of Problem
		O.K.	N.R.	
Natural Mysteries		O.K.	N.R.	
Seri Indian - Wall Story	interactive activity			
Secrets In Shells - Wall Story	interactive activity			
Petroglyphs	Interactive audio			

Appendix D: *Seeing the Unseen* Maintenance Survey

Component	Type	Status		Nature of Problem
		O.K.	N.R.	
Seeing the Unseen		O.K.	N.R.	
Camouflaged Melodies	interactive computer			
Bioscanner (video microscope)	interactive activity			
Polarizer Table	interactive activity			
Bone Stress	interactive model			
Listen Up	interactive activity			
Leonardo's Window	interactive activity			
Hot or Cold	interactive activity			
Touch Sensitivity	interactive activity			
Vibration Sensation	interactive activity			
Smell Survey / computer	interactive activity computer			
Hearing Range	interactive activity (2)			
Color Reversal / computer	interactive activity			
Disappearing Act / computer	interactive computer			
Color Contrast / computer	interactive computer			
Milk Drop - Strobe and Edgerton Crown	interactive model			
Quick As A Wink - Tachistoscope	interactive activity			
Stop the Motion - Spinning Disks	interactive activity			
Whirling Watcher - Phenakistoscope	interactive activity			
Spectra - Gas Discharge Tubes	interactive activity			
Insects - Earthly Aliens (Wentz scope)	interactive activity			
Life in a Drop (Wentz scope)	interactive activity			
BYOS - Klinger inspection scope	interactive activity			
Infrared Light Wall / Camera	interactive activity & graphics			
Where's Waldo	activity with graphics			
The Forest has Eyes	activity with graphics			
Henri Rousseau - The Dream, 1910	activity with graphics			
Giant Lens	interactive activity			
Piano Strobe	interactive activity			
Terrarium	live animals			

Appendix D: *Seeing the Unseen* Maintenance Survey

Component	Type	Status		Nature of Problem
Seeing the Unseen		O.K.	N.R.	
Scanning Electron Microscope	demonstration unit			
Polage Pond	interactive activity			
Its About Time Video	video (interactive)			
Scanning Electron Microscope simulation	interactive computer			

**Exhibit Maintenance Project
Focus Group Questions**

1. What broken exhibits did you find in the galleries?
 - Did you notice anything wrong with the computers? Which ones?
 - Hands-on interactives? Which ones?
 - Signs or labels? Which ones?
 - Missing pieces? What was missing?
 - Audio headphones or buttons? Which ones?
 - Anything else?

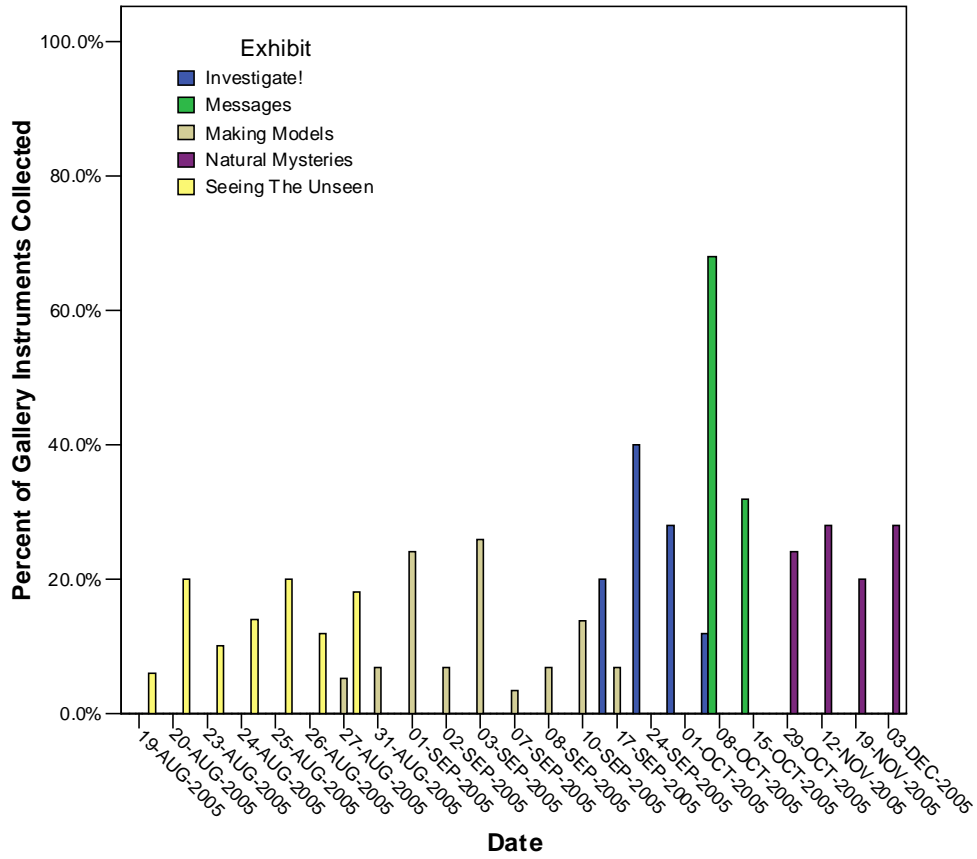
2. What did you do to determine that an exhibit was broken or not working?
 - Did you look at the exhibit?
 - Did you play/interact with the exhibit?
 - Did you watch other people using the exhibit?
 - What else did you do?

3. What criteria did you use to classify something as broken?
 - What were some common things that were broken on exhibits?
 - How did you go about figuring out if something is broken?
 - What cues let you know that something was not working?

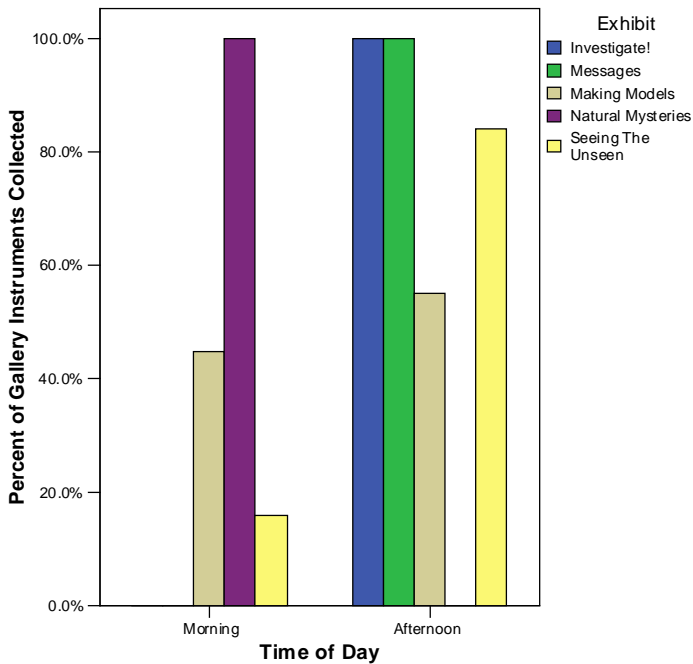
4. How important is it for you that most of the exhibits in the gallery are working?
 - Is it more important that the gallery is fun?
 - Educational?
 - Easy to use?
 - Anything else?
 - What can the museum do to make exhibits better for the visitor?

Appendix F: Data Collection Information

Dates of Map and Interview Collection



Time of Day of Map and Interview Collection



Appendix G: Comment Card Data

Comment Card Report Codes

	Total	Section Total	% of Broken Comments	% of Total Cards	% of Total Comments
Q6: Why was the exhibit called broken?					
1 Nothing was broken					
2 It was broken					
A Obviously broken		30	77	10	11
1 No power / no response / slow response	7		18	2	2
2 Piece missing / need pieces	3		8	1	1
3 Sign on it/roped off	2		5	1	1
4 General	17		44	6	6
5 Other	1		3	0	0
B Not obviously broken		0	0	0	0
1 Piece broken			0	0	0
2 Others might not notice			0	0	0
3 Piece Missing			0	0	0
4 Other (label moved)			0	0	0
5 Computer bug			0	0	0
C It is chronically broken			0	0	0
3 Some other reason					
A Design flaw		15	38	5	5
1 Label					
A No label	2		5	1	1
B Confusing label / directions	2		5	1	1
C Incorrect information	6		15	2	2
D Other (unreadable)	3		8	1	1
2 Activity					
A Difficult to use	1		3	0	0
B Expected result not clear			0	0	0
C Other			0	0	0
3 Other					
A Difficult to use			0	0	0
B Other (bad design)	1		3	0	0
B It was me			0	0	0
1 I didn't do it right			0	0	0
2 I didn't know what to do			0	0	0
3 I don't know English well			0	0	0
4 Other			0	0	0
C Needs to be changed		9	23	3	3
1 It is old / out of date	2		5	1	1
2 Dirty	3		8	1	1
3 In bad shape	3		8	1	1
4 Worked only sometimes	1		3	0	0
4 Mention the action taken		2	5	1	1
A Pushed a button	2		5	1	1
B Picked up a phone			0	0	0
C Played / interacted with it			0	0	0

Appendix G: Comment Card Data

	Total	Section Total	% of Broken Comments	% of Total Cards	% of Total Comments
D Someone else told us			0	0	0
E Other			0	0	0
5 Don't remember what was broken		0	0	0	0
6 Mention / can determine what was broken		34	87	11	12
A Gallery		29	74	10	10
1 Galleries in the study		8	21	3	3
A Making Models	1		3	0	0
B Mapping the World Around Us	2		5	1	1
C Investigate	2		5	1	1
D Seeing the Unseen	1		3	0	0
E Messages			0	0	0
F Natural Mysteries	2		5	1	1
2 Galleries not in the study		17	44	6	6
A A Bird's World	3		8	1	1
B The Lighthouse	1		3	0	0
C Science in the Park	3		8	1	1
D Brain Exhibit	1		3	0	0
E Rock Garden	1		3	0	0
F Butterfly Garden	1		3	0	0
G Mathematica	1		3	0	0
H Optical Illusions	1		3	0	0
I Star Wars	3		8	1	1
J CS&T Stage Area	2		5	1	1
3 Other		4	10	1	1
A Naboo Fighter	2		5	1	1
B Wright 3D Theater	1		3	0	0
C Planetarium	1		3	0	0
B Other		5	13	2	2
1 Microscopes	1		3	0	0
2 Hands-on activities	1		3	0	0
3 Scent exhibits	1		3	0	0
4 Museum kiosk	1		3	0	0
5 Computers	1		3	0	0
6 Other			0	0	0
7 Mention what they feel about broken		12	31	4	4
A Frustrated	1		3	0	0
B Disappointed	9		23	3	3
C Other	2		5	1	1
Q7: Would you like to add anything else?					
8 No		0	0	0	0
9 Yes		3	8	1	1
A About broken exhibits		0	0	0	0
1 In another gallery			0	0	0
2 Didn't notice any			0	0	0
3 Other			0	0	0

Appendix G: Comment Card Data

	Total	Section Total	% of Broken Comments	% of Total Cards	% of Total Comments
A I wasn't paying attention			0	0	0
4 In this gallery					
A Not sure if broken			0	0	0
B Something is confusing			0	0	0
B Not about broken exhibits		3	8	1	1
1 Enjoying the museum/our visit	2		0	1	1
2 Haven't visited much yet			0	0	0
A In the museum			0	0	0
B In this gallery			0	0	0
3 Other		0	0	0	0
A It's for little kids			0	0	0
B It's old			0	0	0
4 Like the exhibit		2	5	1	1
A Interactivity			0	0	0
B Not too busy			0	0	0
C Enjoyable / Fun	1		3	0	0
D Interesting	1		3	0	0
E Like a specific exhibit			0	0	0
F Good gallery			0	0	0
10 What the museum should do		5	13	2	2
A Put a sign on it	1		3	0	0
B Fix it	3		8	1	1
C Clean it	1		3	0	0

Appendix H: Timing and Tracking Map and Exit Interview Data

Investigate! Identified as Broken by Visitors or Evaluators

Investigate!	Number of Visitors Who Called the Exhibit Broken (N=25)	Percent of Visitors Who Called the Exhibit Broken	Number of Times Evaluator Called the Exhibit Broken (N=50)	Percent of Times Evaluator Called the Exhibit Broken	Reason Evaluator Called the Exhibit Broken	Reason Visitor Called the Exhibit Broken
Computers						
Motion Match	1	4%	15	60%	No function	No function
Skin Sensor	1	4%	15	60%	No function	No function
What's Hidden in the Midden?	1	4%	6	24%	Partially functional: Buttons sticking	No function / slow function
Idea Exchange - How do Small Objects Fall?	0	0%	15	60%	Partially functional: Buttons sticking or not collecting data	N/A
Idea Exchange - Solar Car	0	0%	17	68%	Partially functional: Not playing videos / Non-functional	N/A
Idea Exchange - What did you investigate?	0	0%	25	100%	No function: Broken exhibit sign or removed from floor	N/A
Galileo Drop Stop	0	0%	25	100%	Partially functional: Light bulbs out, pieces missing, and/or computer error	N/A
Penny Lab	0	0%	14	56%	Partially functional: Cannot get past weight page	N/A
Survey Survey	0	0%	19	76%	Partially functional: One button not working / Non-functional	N/A
Temperature Investigation	0	0%	8	32%	Partially functional: One probe not working correctly	N/A
Not sure which one	2	7%	N/A	N/A	N/A	N/A
Activities						
Solar Car Area	10	36%	23	92%	No function: Broken exhibit sign or broken car	Broken exhibit sign or broken car
Race of Shapes	4	14%	25	100%	No function: Roped off	Roped off
Pulley Pit Station	2	7%	5	20%	Partially functional: Some weights missing	Design issue: Difficult to use
Midden Dig Site	1	4%	0	0%	N/A	Pieces missing
Ping Pong Probability	1	4%	0	0%	N/A	Ping pong balls broken
Archeology of Us	0	0%	13	52%	Partially functional: Hearphone broken	N/A
Curator Desk Stations	0	0%	5	20%	Partially functional: One phone broken	N/A
Fossil Fern	0	0%	25	100%	Partially functional: Hearphone broken	N/A
Natural Wonders	0	0%	22	88%	Partially functional: Pieces worn out	N/A
Picnic Challenge	0	0%	2	8%	Partially functional: One table cloth missing	N/A
Question Wall	0	0%	8	32%	No function: Pencils missing	N/A
Roll Down Station	0	0%	19	76%	Partially functional: One page of instructions missing	N/A
Zoology Field Station	0	0%	7	28%	Partially functional: One skull missing	N/A
Unknown	5	18%	N/A	N/A	N/A	N/A

Appendix H: Timing and Tracking Map and Exit Interview Data

Making Models Exhibits Broken or Identified as Broken

	Number of Visitors Who Called the Exhibit Broken (N=25)	Percent of Visitors Who Called the Exhibit Broken	Number of Visitors Who Stopped at the Exhibit (N=50)	Percent of Visitors Who Stopped at the Exhibit	Number of Times Evaluator Called the Exhibit Broken (N=50)	Percent of Times Evaluator Called the Exhibit Broken	Reason Evaluator Called the Exhibit Broken	Reason Visitor Called the Exhibit Broken
Making Models								
Computers								
Cookie: Take It or Leave It	2	29%	8	14%	58	100%	Partially functional: some buttons not working / No function	No function
Money: Compete or Cooperate	1	14%	6	11%	58	100%	Partially functional: some buttons not working / No function	Buttons did not work
A World of Maps	0	0%	11	19%	2	3%	Partially functional: menu seen on screen	N/A
Where Am I? Modeling as Sound	0	0%	3	5%	58	100%	Partially functional: one button broken	N/A
Activities								
Mapping the Coast	1	14%	16	28%	12	21%	Partially functional: one chain missing	Chain missing
Mt. Champlain Trails	1	14%	20	35%	0	0%	N/A	Design issue: Expected result unclear
Teeth / Toothbrush Model	1	14%	8	14%	58	100%	Partially functional: teeth broken	Teeth broken
What Time Is It? Modeling Time of Day	1	14%	7	12%	0	0%	N/A	Design issue: Appeared non-functional
Blowing in the Wind	0	0%	14	25%	3	5%	Partially functional: Light bulb out	N/A
Cake Packaging Activity	0	0%	2	4%	4	7%	Partially functional: Graphic label broken	N/A
Construction Site Mystery Scene	0	0%	13	23%	26	45%	Partially functional: Audio very quiet or not working	N/A
Duck Models	0	0%	15	26%	2	3%	Partially functional: one button slow	N/A
Grasshopper and Train Models	0	0%	26	46%	54	93%	Partially functional: spine missing on grasshopper / Non-functional: Train off track	N/A
Heart Models	0	0%	18	32%	40	69%	Partially functional: doors sticking / audio not working	N/A
Seascape Mystery Scene	0	0%	7	12%	55	95%	Partially functional: Audio broken and/or one touch object missing	N/A
STM: The Atomic Model	0	0%	7	12%	51	88%	Partially functional: pieces missing and/or audio broken	N/A

Appendix H: Timing and Tracking Map and Exit Interview Data

Messages Identified as Broken by Visitors or Evaluators

Messages	Number of Visitors Who Called the Exhibit Broken (N=25)	Percent of Visitors Who Called the Exhibit Broken	Number of Times Evaluator Called the Exhibit Broken (N=50)	Percent of Times Evaluator Called the Exhibit Broken	Reason Evaluator Called the Exhibit Broken	Reason Visitor Called the Exhibit Broken
Computers						
Watch Yourself	5	28%	13	52%	Partially functional: Picture blurry and sound is poor / Non-functional	No function
Language to Go Diner	3	17%	17	68%	No function	No function
Are You Talking To Me?	2	11%	9	36%	Partially functional: Audio quiet / Non functional	No function
Beehive Camera	1	6%	17	68%	No function	No function
Get the Picture Computer	0	0%	25	100%	Partially functional: Cannot view others' collages	N/A
Message Web Site / 6 Degrees of Separation	0	0%	25	100%	Partially functional: Keyboard not working and/or slow functioning	N/A
SETI Computer	0	0%	20	80%	Partially functional: Looking up message is very slow	N/A
The Talking Map	0	0%	9	36%	Partially functional: Audio labels not working correctly	N/A
Not sure which one	1	6%	N/A	N/A	N/A	N/A
Activities						
Get the Picture Collage Sheets	1	6%	0	0%	N/A	Other problem: Area messy
What's the Message?	1	6%	0	0%	N/A	Hearphone broken
Hobo Code Flip Panels	0	0%	25	100%	Partially functional: Graphic on one panel ripped	N/A
Videos						
A Visual Language	1	6%	0	0%	N/A	Design issue: Appeared non-functional
Unknown	3	17%	N/A	N/A	N/A	N/A

Appendix H: Timing and Tracking Map and Exit Interview Data

Seeing the Unseen, Making Models, and Investigate! Exit Interview Coding Data

	STU Total	STU Section Total	STU % of Interviews	MM Total	MM Section Total	MM % of Interviews	Inv Total	Inv Section Total	Inv % of Interviews
Q6: Why was the exhibit called broken?									
1 Nothing was broken		13	52%		19	76%		9	36%
2 It was broken									
A Obviously broken		6	24%		5	20%		21	84%
No power / no response / slow									
1 response	6		24%	3		12%	6		24%
2 Piece missing / need pieces			0%	2		8%	3		12%
3 Sign on it/roped off			0%			0%	8		32%
4 General			0%			0%	3		12%
5 Other			0%			0%	1		4%
6 Maintenance was working on it			0%			0%			0%
C It is chronically broken			0%			0%		2	8%
3 Some other reason		13	52%		3	12%		1	4%
A Design flaw		7	28%		2	8%		1	4%
1 Label		0	0%		0	0%		0	0%
A No label			0%			0%			0%
B Confusing label / directions			0%			0%			0%
C Incorrect information			0%			0%			0%
D Other (unreadable)			0%			0%			0%
2 Activity		7	28%		2	8%		1	4%
A Difficult to use	4		16%			0%	1		4%
B Expected result not clear	3		12%	1		4%			0%
C Other			0%	1		4%			0%
B It was me		5	20%		1	4%		0	0%
1 I didn't do it right	1		4%			0%			0%
2 I didn't know what to do	1		4%			0%			0%
3 I don't know English well	1		4%			0%			0%
4 I'm not sure if it's broken	1		4%	1		4%			0%
5 I didn't understand	1		4%			0%			0%
C Needs to be changed		1	4%		0	0%		0	0%
1 It is old / out of date	1		4%			0%			0%
2 Dirty			0%			0%			0%
3 In bad shape			0%			0%			0%
4 Worked only sometimes			0%			0%			0%
4 Mention the action taken		2	8%		1	4%		4	16%
A Pushed a button	1		4%	1		4%	2		8%
B Picked up a phone			0%			0%	1		4%
C Played / interacted with it			0%			0%			0%
D Someone else told us			0%			0%	1		4%
E Tried everything	1		4%			0%			0%
5 Don't remember what was broken		1	4%			0%		5	20%
7 Mention what they feel about broken		0	0%		0	0%		0	0%
A Frustrated			0%			0%			0%
B Disappointed			0%			0%			0%
C Other			0%			0%			0%

Appendix H: Timing and Tracking Map and Exit Interview Data

	STU Total	STU Section Total	STU % of Interviews	MM Total	MM Section Total	MM % of Interviews	Inv Total	Inv Section Total	Inv % of Interviews
Q7: Would you like to add anything else?									
8No		9	36%		13	52%		11	44%
9Yes		16	64%		12	48%		14	56%
A About broken exhibits		14	56%		8	32%		14	56%
1 In another gallery	5		20%	2		8%	4		16%
2 Didn't notice any	5		20%	3		12%	4		16%
3 Other			0%			0%			0%
A I wasn't paying attention	1		4%	1		4%	1		4%
B Didn't notice more	1		4%			0%			0%
C Another museum has lots of broken exhibits			0%	1		4%			0%
4 In this gallery			0%			0%			0%
A Not sure if broken	2		8%			0%	1		4%
B Something is confusing			0%	1		4%			0%
C Lumped exhibits together			0%			0%	4		16%
B Not about broken exhibits		11	44%		9	36%		9	36%
1 Enjoying the museum/our visit		3	12%			0%			0%
2 Haven't visited much yet		3	12%		2	8%		2	8%
A In the museum	1		4%	1		4%	2		8%
B In this gallery	2		8%	1		4%			0%
3 Other		1	4%		3	12%		4	16%
A It's for little kids			0%	3		12%	2		8%
B It's old	1		4%			0%	1		4%
C Other			0%			0%	1		4%
4 Like the exhibit		4	16%		4	16%		3	12%
A Interactivity	2		8%	1		4%	1		4%
B Not too busy	1		4%			0%			0%
C Enjoyable / Fun	1		4%	1		4%			0%
D Interesting			0%	1		4%	1		4%
E Like a specific exhibit			0%			0%			0%
F Good gallery			0%	1		4%	1		4%
10 What the museum should do		0	0%		0	0%		0	0%
A Put a sign on it			0%			0%			0%
B Fix it			0%			0%			0%
C Clean it			0%			0%			0%
11 Make a joking statement		1	4%			0%			0%

Appendix H: Timing and Tracking Map and Exit Interview Data

Messages, Natural Mysteries, and Overall Exit Interview Coding Data

	Mess Total	Mess Section Total	Mess % of Interviews	NM Total	NM Section Total	NM % of Interviews	Total	% of Interviews
Q6: Why was the exhibit called broken?								
1 Nothing was broken		13	52%		16	64%	70	56%
2 It was broken								
A Obviously broken		12	48%		9	36%	53	42%
No power / no response / slow								
1 response	9		36%	4		16%	28	22%
2 Piece missing / need pieces			0%	2		8%	7	6%
3 Sign on it/roped off			0%			0%	8	6%
4 General	1		4%	3		12%	7	6%
5 Other	1		4%			0%	2	2%
6 Maintenance was working on it	1		4%			0%	1	1%
C It is chronically broken			0%			0%	2	2%
3 Some other reason		5	20%		2	8%	24	19%
A Design flaw		2	8%		2	8%	14	11%
1 Label		0	0%		1	4%	1	1%
A No label			0%			0%	0	0%
B Confusing label / directions			0%			0%	0	0%
C Incorrect information			0%	1		4%	1	1%
D Other (unreadable)			0%			0%	0	0%
2 Activity		2	8%		1	4%	13	10%
A Difficult to use	1		4%			0%	6	5%
B Expected result not clear	1		4%			0%	5	4%
C Other			0%	1		4%	2	2%
B It was me		2	8%		0	0%	8	6%
1 I didn't do it right			0%			0%	1	1%
2 I didn't know what to do	2		8%			0%	3	2%
3 I don't know English well			0%			0%	1	1%
4 I'm not sure if it's broken			0%			0%	2	2%
5 I didn't understand			0%			0%	1	1%
C Needs to be changed		1	4%		0	0%	2	2%
1 It is old / out of date			0%			0%	1	1%
2 Dirty	1		4%			0%	1	1%
3 In bad shape			0%			0%	0	0%
4 Worked only sometimes			0%			0%	0	0%
4 Mention the action taken		6	24%		4	16%	17	14%
A Pushed a button	6		24%	4		16%	14	11%
B Picked up a phone			0%			0%	1	1%
C Played / interacted with it			0%			0%	0	0%
D Someone else told us			0%			0%	1	1%
E Tried everything			0%			0%	1	1%
5 Don't remember what was broken		3	12%		2	8%	11	9%
7 Mention what they feel about broken		0	0%		0	0%	0	0%
A Frustrated			0%			0%	0	0%
B Disappointed			0%			0%	0	0%
C Other			0%			0%	0	0%

Appendix H: Timing and Tracking Map and Exit Interview Data

	Mess Total	Mess Section Total	Mess % of Interviews	NM Total	NM Section Total	NM % of Interviews	Total	% of Interviews
Q7: Would you like to add anything else?								
8No		17	68%		17	68%	67	54%
9Yes		8	32%		8	32%	58	46%
A About broken exhibits		3	12%		4	16%	43	34%
1 In another gallery	3		12%	3		12%	17	14%
2 Didn't notice any			0%	1		4%	13	10%
3 Other			0%			0%	0	0%
A I wasn't paying attention			0%			0%	3	2%
B Didn't notice more			0%			0%	1	1%
C Another museum has lots of broken exhibits			0%			0%	1	1%
4 In this gallery			0%			0%	0	0%
A Not sure if broken			0%			0%	3	2%
B Something is confusing			0%			0%	1	1%
C Lumped exhibits together			0%			0%	4	3%
B Not about broken exhibits		4	16%		5	20%	38	30%
1 Enjoying the museum/our visit		1	4%			0%	4	3%
2 Haven't visited much yet		0	0%		3	12%	10	8%
A In the museum			0%	2		8%	6	5%
B In this gallery			0%	1		4%	4	3%
3 Other		1	4%		2	8%	11	9%
A It's for little kids			0%			0%	5	4%
B It's old			0%			0%	2	2%
C Other	1		4%	2		8%	4	3%
4 Like the exhibit		2	8%		0	0%	13	10%
A Interactivity			0%			0%	4	3%
B Not too busy			0%			0%	1	1%
C Enjoyable / Fun			0%			0%	2	2%
D Interesting			0%			0%	2	2%
E Like a specific exhibit	1		4%			0%	1	1%
F Good gallery	1		4%			0%	3	2%
10What the museum should do		1	4%		0	0%	1	1%
A Put a sign on it			0%			0%	0	0%
B Fix it			0%			0%	0	0%
C Clean it	1		4%			0%	1	1%
11Make a joking statement			0%			0%	1	1%

Appendix I: Maintenance and Visitor Survey Data

Making Models Results from Maintenance, Visitor/Member, and Fenway Surveys

	Maintenance Workers (N = 8)	Visitor/ Members (N = 4)	Fenway Students (N = 6)	Problem	Reason for Discrepancy
Making Models					
Giant Grasshopper	0	0	0		
Honey I Shrunk the Locomotive	1	0	6	Maintenance: train sticks; Visitor: button doesn't work	Chronically broken
Helicopter Video	0	0	1	Couldn't find the exhibit	Visitor couldn't find the exhibit so marked it broken
Intro Wall Models (6 models)	0	1	0	Lights flickering	Broke between exhibit checks
Models Can Take Us Back In Time- Great Plains	0	0	1	Does not turn completely	Don't understand visitor comment
What Is A Model (8 buttons/panels)	0	1	0	Had to press button several times	Experience did not match visitor expectation
Packaging (2 stations)	0	0	0		
Fish Farming	0	0	0		
Heart Models (8 stations)	2	2	0	Maintenance: being repaired; Visitor: one hearphone broken	Noticed different problems: one maintenance rarely catches; the other visitors rarely catch
Me Vs Us: Take It Or Leave It	0	0	0		
Me Vs Us: Compete Or Cooperate	0	0	0		
What Time Is It	0	0	0		
Where Am I	0	0	1	Up button doesn't work	Maintenance didn't record problems with bugs or content
Can You Make A Model Of (5 stations)	0	0	0		
Model Stories	0	0	0		
Mystery Object - Book	0	0	0		
Mystery Object - Hammer	0	0	0		
Mystery Scene - Construction Site	0	0	0		
Mystery Scene - Lobster Boat	1	1	0	Maintenance: object missing; Visitor: hearphone broken	Noticed different problems: one maintenance rarely catches; the other visitors rarely catch
Which Model Is Best?	0	0	0		
This Is A Model Of...?	0	0	0		
Flying Over The Atomic Landscape	0	1	3	Hearphone broken; monitor off	Maintenance didn't record problems with bugs or content
Shape Is Key	0	0	0		
Wave Tank	0	0	0		

Appendix I: Maintenance and Visitor Survey Data

Making Models (cont'd)	Maintenance Workers (N = 8)	Visitor/ Members (N = 4)	Fenway Students (N = 6)	Problem	Reason for Discrepancy
Models That Explain Case	0	1	1	Missing acupuncture head	Maintenance didn't record problems with static object cases
Models That Teach Case	0	1	0	Label is on the ground	Maintenance didn't record problems with static object cases
Models That Teach- Teeth & Toothbrush	1	0	2	Needs new teeth	Obviously broken
Models At Play Case	0	1	0	Audio too loud and staticky	Experience did not match visitor expectation
Models at Play- Mayan Pyramid	0	2	0	Audio too loud and staticky	Experience did not match visitor expectation
23 Scraps Of Paper	0	0	0		
Models At Work Case	0	0	0		
Blowing In The Wind	0	0	0		
Creating A Model - Pyramids at Giza	0	0	0		
Total	5	11	15		Visitor found more broken than maintenance

Appendix I: Maintenance and Visitor Survey Data

Seeing the Unseen Results from Maintenance and Fenway Surveys

The Observatory- Seeing the Unseen	Maintenance Workers (N = 6)	Fenway Students (N = 4)	Problem	Reason for Discrepancy
Whose Woods Are These?	0	0		
Henri Rousseau - The Dream, 1910	0	0		
Touch Sensitivity	0	0		
Where's Waldo	0	0		
Hot or Cold	0	0		
Motion Detector	0	0		
Stop the Motion	0	0		
Whirling Watcher	0	0		
It's About Time	0	0		
Piano Strobe	0	2	Strobe frequency knob not working	Experience did not match visitor expectation
Scanning Electron Microscope	1	0	Needs new TV	Visitors didn't notice this
Mummy Video	0	3	Error on screen	Broke between exhibit checks
Leonardo's Window	1	0	Needs new footprints	Visitors didn't notice this
Learning to Look: The Forest has Eyes	0	0		
Camouflaged Melodies	0	0		
Dark Light	0	0		
Reflecting Pond	0	0		
Bioscanner	1	2	Knob missing	Obviously broken
Playing with Polarizing Light (2 stations)	1	0	On one side lever is not connected	Visitors didn't notice this
Bone Stress	0	0		
Listen Up	0	1	Lights not working	Experience did not match visitor expectation
Spectra	0	0		
Vibration Sensation	1	0	Not vibrating	Broke after visitors went through
Smell Survey	0	0		
Hearing Range (2 stations)	1	0	Should be range we can't hear	Visitors didn't notice this
Reverse Distance	0	0		
Color Reversal	1	0	Light bulb not working	Broke after visitors went through
Disappearing Act	0	0		
Visible Effects of Invisible	1	0	Clear overlay missing corner	Visitors didn't notice this
Splash in a Flash	0	0		
Quick As A Wink	0	0		
Giant Magnifying Glass	0	0		
Infrared Camera & Light Wall	1	0	Rubber bumpers in front need replacing	Visitors didn't notice this
Insects - Earthly Aliens Microscope	0	2	Labels ripped off	Maintenance didn't record problems with bugs or content
BYOS - Bring Your Own Stuff Microscope	1	0	Missing handle	Visitors didn't notice this
Life in a Drop of Pondwater Microscope	0	3	Labels ripped off	Maintenance didn't record problems with bugs or content
Total	10	13		Maintenance and visitors found about the same amount of exhibits broken

Fenway High School Focus Groups

Key Themes from Fenway High School Focus Group #1 (September 20, 2005)

This focus group discussed the *Messages* and *Investigate!* galleries.

- They talked about problems with non-functioning computers.
 - “One [computer] didn’t work. They’re frozen.”
 - “The motion match... when you walked the computer wouldn’t sense you.”
(*Investigate*)
- They talked about problems with partially functioning computers.
 - “Before you get in, the computer that you touch, the talking map, it’s wrong, it was in the wrong place.” (*Messages*)
 - “Get the picture—only let you choose make it and not guess.” (*Messages*)
 - “The computers were slow”
 - “Update the computers”
 - “Galileo Drop... right side wasn’t working. It was graphing negative numbers.” (*Investigate*)
- They talked about using buttons to tell if an exhibit is broken.
 - “Press it [the buttons] multiple times”
 - “How do objects fall [computer] had to press that button 10 times to get it to work. With hyper kids that would work, but not with other people.”
(*Investigate*)

Key Themes from Fenway High School Focus Group #2 (September 20, 2005)

This focus group discussed the *Making Models* and *Seeing the Unseen* galleries.

- They mentioned that they had difficulty testing the function of static exhibits.
 - “Some of the artifacts, we don’t know if it’s working because we can’t interact with them, so we don’t know if they’re working or not.” (*Making Models*)
 - “Tapped the glass to see if any water leaked out.” (*Making Models*)
- They talked about missing pieces or objects.
 - “On the toothbrush thing [in *Making Models*], the front teeth were broken.”
 - “Some of the animals were missing [*Seeing the Unseen*] I looked and they definitely weren’t there.”
 - “Some of the beads were missing [*Making Models*—“Can you make a model of”] from a bin.”

Visitor/Member Focus Groups

Key Themes from Visitor/Member Focus Group #1 (October 8, 2005)

This focus group discussed the *Messages* gallery.

- They talked about problems with old computers.
 - “I understand they’re older computers, but [the interactions] need to be spontaneous. The resolution needs to be set higher, so you don’t have to scroll [horizontally]. Can read $\frac{3}{4}$ of a sentence and then you have to scroll further. Can get the equipment for \$3 on eBay.” (“6 Degrees of Separation” exhibit)
 - “You’ve got to be dedicated to stay At the Exploratorium, 20-30% of stuff is busted when you get there, but its okay. There’s a homemade flavor, you expect stuff to be broken. No fun to go up to stuff that’s slow. If it’s 1990s technology, it’s got to go. Right into the Charles. It’s fine if it’s fast, but 1 person in 1800 is going to wait.”
- They talked about slow computers.
 - “Too slow; I waited 3 minutes.” (“SETI Computer” exhibit)
 - “Unresponsive, too slow to be relevant.”
 - “Things are slow.”
- Talked about other computer bugs.
 - “Get the picture computer can’t save your collage or look at other’s collages.”
 - “See your own, but you can’t see others.” (“Get the Picture” computer exhibit)
 - “It said you could see other people’s collages, but you couldn’t.” (“Get the Picture” computer exhibit)
- They talked about audio problems.
 - “Speaker mounted vertical sound came out. It seemed like some bypassed the hearphone.” (“Are You Talking to Me?” Computer exhibit)
 - “Listening to different accents hard to hear because of noise levels. It would have benefited from headphones so there was something other than sound coming form above.”
 - “Things were too hard to hear, there could be two levels of sound. The visual language movie the ASL was really loud. It was great. The first exhibit outside, the talking map, was hard to hear.”
 - “The sound was hyperbolic—half of the room could hear it.”
 - “When we were alone in the exhibit, you could easily hear, but when it got busier, things were harder to hear. The hearing cups were helpful. Some of us mentioned headphones. It would be good if future exhibits had them for when it gets busy. They would be easy to maintain. I think in one area, make sure the audio is audible. When the exhibit got too loud, I couldn’t hear at all. In the audio piece especially when the exhibit got too loud.”

Key Themes from Visitor Focus Group #2 (October 15, 2005)

This focus group discussed the *Making Models* gallery.

- They talked about problems with labels and cases.

Appendix J: Focus Group Data

- “There was a tag for an acupuncture head, but there was nothing there.” (“Models that Explain” case)
- “The label for the ear was on the ground while the ear was on the shelf.” (“Models that Teach” case)
- “Did you know there were only 22 scraps?” (“23 Scraps of Paper”)
- “Maybe you should look into that...” (In response to previous comment)
- “If it wasn’t labeled right, or you couldn’t hear it. Those were the two main things for me.”
- They talked about problems and concerns with buttons.
 - “I found you had to push the buttons a lot of times.” (Talking about computer interactives)
 - “The whoopee cushion button I pushed several times and had to hold the button down for the woman to speak.” (“What is a Model?” Exhibit)
 - “One of the buttons was sticking.”
 - “Press the buttons. A lot of the exhibits didn’t have interaction that made it harder to tell if it’s supposed to work.” (In response to a question about how they tested exhibits)
 - “Yeah, the kids push the buttons hard—it’s not right.”
- They talked about audio problems.
 - “The pyramid diorama audio text label was incredibly loud.”
 - “Same with the Fish Farming.” (In response to previous statement)
 - “I found some of the audio to be staticky. Also, the Lobster scene the headphone on the left side didn’t work.”
 - “It worked for me.” (In response to previous statement)
 - “I noticed that Shape is the Key the audio constantly repeats itself. This is the same for the teeth. People would come in in the middle of the audio and have to wait to hear the entire label. It wasn’t consistent with the others [headphones].”
 - “‘Flying the Atomic Landscape’ couldn’t get the audio to work.”
 - “If it wasn’t labeled right, or you couldn’t hear it. Those were the 2 main things for me.”
 - “Some was incredibly loud like the fish farming.”
 - “How do you regulate it? I’m surprised there were different audio levels.”
 - “I noticed that when some of the women were speaking they were hard to hear [on the headphones], but when the man was speaking it was easier.”

Interpretation Volunteer Focus Groups

Key Themes from Interpretation Volunteer Focus Group #1 (October 20, 2005)

This focus group discussed the *Investigate!* gallery.

- They talked about concerns with computers.
 - “Tend to be computer exhibits—need to be better tested or go around every morning to check them.”
 - “Science in the Park—computer needs to be rebooted.”
 - “Gravity drop never works. The computer is broken, and it takes a lot of abuse.”
 - “Is the computer on and working?” (In response to a question about how you determine if an exhibit is working)
- They talked about poor mechanical design.
 - “Change the coaxial cable, multiple conductors. It would be more flexible and last longer.”
 - “The Bioscanner, looking at lizards, keeps deteriorating—less motion is possible—focus is back.”
 - “The design was not engineered properly. Should be tested by the bunch of volunteers you’ve got up here.”
- They talked about problems with exhibit instructions.
 - “Some instructions could be re-worked. Kids don’t look at instructions. They need staff there to show them what to do. They just bang.”
 - “Frozen shadows—don’t tell you to turn around and look at the screen, so your eyes get blinded by the light.”
 - “Solar cars and other interactives need a volunteer or staff instruction. Kids just throw things together. Also, People who did the label tried to get too smart—the questions and instructions are too complex.”
- They talked about kids abusing exhibits.
 - “Gravity drop never works. The computer is broken, and it takes a lot of abuse.”
 - “Those cars have never worked—the solar cars. The rubber band always comes off, never works. It is subject to so much abuse, kids just push them.”
 - “Seeing the unseen—The infrared TV camera gets banged up badly. The kids don’t use it correctly and swing it around.”

Key Themes from Interpretation Volunteer Focus Group #2 (October 21, 2005)

This focus group discussed the *Investigate!* gallery.

- They talked about kids abusing exhibits.
 - “The big beam kids like to hang off like monkeys... it would help to have the weight a little lighter so that you could see it lifting off the ground. If you could give the ratio somewhere of fulcrum to arm at 2 or 3 positions. They’re all jumping around and getting no progression. The scale there is worthless. The scale doesn’t tell how much force.”

Appendix J: Focus Group Data

- “Extensive reports. I don’t want to go in there some days—Science in the Park takes such abuse from visitors. In there, computer problems, 1 unit completely dependent on “place yourself” – One day last week took the cake, anything satisfying solar energy would work.”
- “In the Lighthouse, there is one that is abused more than used. Leslie and Jeff are great at responding. I call Maintenance and have the lights turned back on.”
- They talked about incorrect instructions.
 - “I looked at the placard on the wall and it says to adjust the light. From the placard it sounds like it wants you to move the light, but you can’t. I saw Bill and asked if you could put a piece of tape over it because that’s a good demo. No one went over there because everyone went over to the incline plane.”
 - “Read the instructions, try to follow it, and if you can’t complete the maneuver then it’s broken because I can’t follow it.”
- They talked about improving labels.
 - “The mummy display... The museum can do a lot by reducing the amount of text that people have to read. Make it more concise rather than having to spend 10 minutes. Maybe you could include some connection to average day applications. Instead it’s which rolls faster.” (*Seeing the Unseen*)
 - “If see placard, too many small words. If bring up some catchy statement, it catches your attention, curiosity and you continue to read. Like leading a horse to water, some may add.”
- They talked about adding more interpretation into galleries.
 - “That is a good place to interpret. Most people don’t stop to think. Kids say it’s a good place to fool around. You have to say, ‘Hey, where else have you seen this.’”
 - “Inclined plane is a good place to have interpretation. Explain the concept of friction with the wheels—knobby or smooth. Again, it’s very subjective.” (*Investigate!*)

Key Themes from Interpretation Volunteer Focus Group #3 (October 25, 2005)

This focus group discussed the *Messages* gallery.

- They talked about problems with labels.
 - “One thing I notice is signage is not so good.”
 - “Someone pointed out how many calories... but never said how long it takes to burn them off.” (Labels at obesity exhibit near CS&T stage)
 - “Another trend is that the exhibit gets changed, but the label doesn’t—it’s frustrating.”
 - “I’d like it if people could pick the level of instruction that they want. Have a button that says, ‘I’m confused’ or ‘You’re boring me’ Something that allows you to go up 3 levels. But, you’d have to trust the technology. It may not be too far off.”
 - “Sometimes I think visitors not understanding makes things broken. Make sure the directions are clear and stand out from the rest.”

Appendix J: Focus Group Data

- “That’s a place I consider the labeling to be broken. It’s not clear what you should do with the wall.” (“Infrared Camera” in *Investigate!*)
- They talked about problems with computer exhibits.
 - “One computer-based interactive wanted you to download something—flash.” (*Messages*)
 - “Not functioning.” (In response to the question did you see anything wrong with computers)
 - “I see a lot of notices on the [computer] screens.”
 - “Again, older computers get hung up.”
 - “I think it’s the hard drive.”
 - “If there’s nothing on the screen.” (In response to the question ho do you determine if something is broken)
 - “It would be nice to have easy access to reboot computers. Sometimes, it just needs a reboot. Sometimes it’s so frustrating a visitor tries so long for a simple problem.”
 - “I wonder if there could be more standardization on the computer. The more computers standardized the better.”
- They talked about current maintenance procedures.
 - “Trouble with remote box is 10 o’clock find a nonfunctioning exhibit and by the time you get to the cafeteria you forget and don’t know enough details to describe it. I don’t know if it’s disillusioning to have boxes. Part of it is staff touring. Some things are out for days and days and days. Sometimes, I wonder if I need to kick it.”
 - “Years ago I talked to exhibit maintenance and they make a report weekly. Used to mark call chamber out all the time, but they built a wall around it so we couldn’t use it. Finally, they took it down.”
 - “Some of the computers have a little logbook, but some people pull the plug and put it back in, and I don’t think that gets logged.”
- They talked about visitors not using exhibits properly.
 - “Sometimes things don’t last long because children bang on it.”
 - “See if folks see people use it improperly, who to give this information to, ‘Hey, visitors are using this incorrectly.’”
 - “Infrared camera—The design breaks—people use too much force.”
 - “You know what’s abused? The map [near the Information Desk]... kids are always belting it at any given time. They’re not even looking at it yet it is always working. Of course, it’s just a series of on-off switches. What never working is the solar cars.”