Electric Space: A Summative Evaluation

Prepared for
The Space Science Institute

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INTRODUCTION

This report presents findings from a summative evaluation of *Electric Space*, a traveling exhibition developed by the Space Science Institute, with major funding provided by the Informal Science Education Program of the National Science Foundation. This study is the third phase of evaluation conducted by Randi Korn & Associates in association with this project. After performing both front-end and formative evaluations during the exhibition development process, this summative study was conducted on the completed traveling version of *Electric Space* at two host sites. This final study was undertaken to document the scope of the exhibition's impact and effectiveness.

The specific goals of the summative evaluation were to

- determine which components are most successful at attracting visitors
- gauge how long visitors spend at different components
- understand what meaning visitors create from the exhibition
- determine whether visitors had any difficulty using the interactive components
- determine whether visitors had any difficulty reading the interpretive text
- uncover what visitors like about *Electric Space*
- solicit visitors' ideas regarding what parts of the exhibition need to be improved
- gauge visitors' enjoyment of the exhibition.

DESCRIPTION OF THE EXHIBITION

One of the goals of *Electric Space* is to help visitors understand space science as an exciting, interdisciplinary field. The exhibition consists of the following distinct modules:

1. **Welcome to Electric Space** explains that space is not empty, rather it is filled with magnetic fields, fast-moving electrically charged particles, and plasma.
2. **The Plasma State of Matter**, defines, provides examples of, and demonstrates properties of plasma, magnets, and electricity.
3. **Our Dynamic Sun** describes characteristics of the sun, relating how it has been an object of study since ancient times and identifying such phenomena as the solar wind, sunspots, and solar flares.
4. **Planet Earth, the Great Magnet**, presents the magnetosphere, ionosphere, space weather, radiation, and auroras.

5. **Reaching for the Stars** introduces the heliosphere, magnetospheres of other stars, planets and galaxies, and the dangers of electric space.

Included throughout the exhibition are text panels with brilliant graphic images, interactive components, and videos.

A few differences that existed between the two installations should be noted. At the Virginia Air & Space Center (VASC), two interactive components (Kinetic Theory and Magnetic Attraction/ Repulsion) were not a part of the exhibition and the Violet Plasmasphere was placed at a distance from the rest of the exhibition. Therefore, these three interactives were not included in that site's data analysis. At the Maryland Science Center (MSC), the Headphones were not available at the Shortwave Radio and Radio Interference component and the Bar Magnet and Compasses interactive was located outside of the entrance to the exhibition; hence, these two components were not a part of MSC's data analysis.

METHODOLOGY

Two data collection strategies were employed to assess visitors' use of and experiences with *Electric Space*: timing and tracking observations and open-ended interviews.

Timing and Tracking Observations

Visitors are often observed in summative evaluations because observations provide an objective and quantitative account of how visitors behave and react to exhibition components. Observational data suggest the range of visitor behaviors occurring in the exhibition and indicate which components attract, as well as hold, the most and least attention.

All adult visitors 16 years of age and older were eligible to be unobtrusively observed as they toured *Electric Space*. The observed individuals were selected by following a continuous random sampling method. In accordance with this method, a trained observer was stationed at the entrance to *Electric Space*. The first adult visitor to enter the exhibition was observed. The observer followed the selected individual through the exhibition, recording components at which he or she stopped, time spent at individual components, and total time spent in the exhibition (see Appendix A for a sample tracking form). Upon the completion of a visit, the observer returned to the entrance to await the next adult visitor to enter the exhibition.

Open-ended Interviews

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

After visiting *Electric Space*, individual adults (16 years of age and older) were selected (following a continuous random sampling method, as described above) and asked to answer a few questions (see Appendix B for a copy of the interview guide). The interview guide was intentionally open-ended to allow interviewees the freedom to discuss what they felt was meaningful. All interviews were tape-recorded with participants' awareness and transcribed to facilitate analysis.

DATA ANALYSIS

Quantitative data were entered into a computer and analyzed statistically. Percents and summary statistics, including the median (point at which half the responses fall above and half fall below), mean (average), and standard deviation (spread of scores: ±) were calculated for interval and ratio variables. To compare the means of two visitor subsets (e.g., visitor groups with children and those without), *t*-tests were computed.

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

The verbatim responses to the interview questions were analyzed qualitatively, meaning that the evaluator studied the responses for meaningful patterns. As patterns and trends emerged, similar responses were grouped together. Each grouping was then assigned a name or category that conveys the meaning the responses embody.

METHOD OF REPORTING

The data presented in this report are both quantitative and qualitative in nature. Findings from the timing and tracking observations are presented first, followed by findings from the interviews. For the quantitative data, tables and figures are regularly used to display the information in a manner that makes it easily accessible. Percentages within tables may not always equal 100.0 due to rounding. The findings within each topic are presented in descending order, starting with the most frequently occurring. Interviewees' verbatim quotations (edited for clarity) are used to illustrate major trends in the data and to convey visitors' thoughts and feelings as fully as possible.

Findings are reported in two main sections as follows:

I. Timing and Tracking Observations

II. Open-ended Interviews

PRINCIPAL FINDINGS

I. TIMING AND TRACKING OBSERVATIONS

Visitor Characteristics

In total, 100 adults (17 years and older) were unobtrusively observed as they toured *Electric Space*. At the Virginia Air and Space Museum, 35 visitors were tracked; at the Maryland Science Center, 65 visitors were tracked. With a sample size of 100, percentage of visitors equals the actual number of visitors. So, in the remainder of the tracking report, the terminology is used interchangeably.

As shown in Table I.1, overall there were slightly more males than females (58 percent and 42 percent, respectively). More than two-thirds of the observed visitors were between the ages of 25 and 44. Over three-quarters were white (85 percent).

Table I.1.
Demographic Characteristics in Percent

Characteristic	%
Gender	
Male	58.0
Female	42.0
Age	
17 – 24	14.0
25 – 34	31.0
35 – 44	40.0
45 – 54	9.0
55+	6.0
Ethnicity	
White	85.1
Black/African American	5.7
Asian	5.7
Latino/Hispanic	1.1
Other	2.3

As noted in Table I.2, half of those observed were visiting with one other adult (50 percent). One-third of visitors were the only adult in their visitor group (35 percent). Almost one-half of visitors were visiting without children (45 percent). Of the children present in the groups, nearly two-thirds were between the ages of 4 and 9 years (63 percent).

Table I.2.
Visitor Group Composition in Percent

Number of Adults in Group	**%**
One	35.0
Two	50.0
Three	10.0
Four	5.0
Number of Children in Group	**%**
None	45.0
One	30.0
Two	19.0
Three or more	6.0
Ages of Children (in Years)	**%**
1 – 3	12.4
4 – 6	23.6
7 – 9	39.3
10 – 12	18.0
13 – 15	6.7

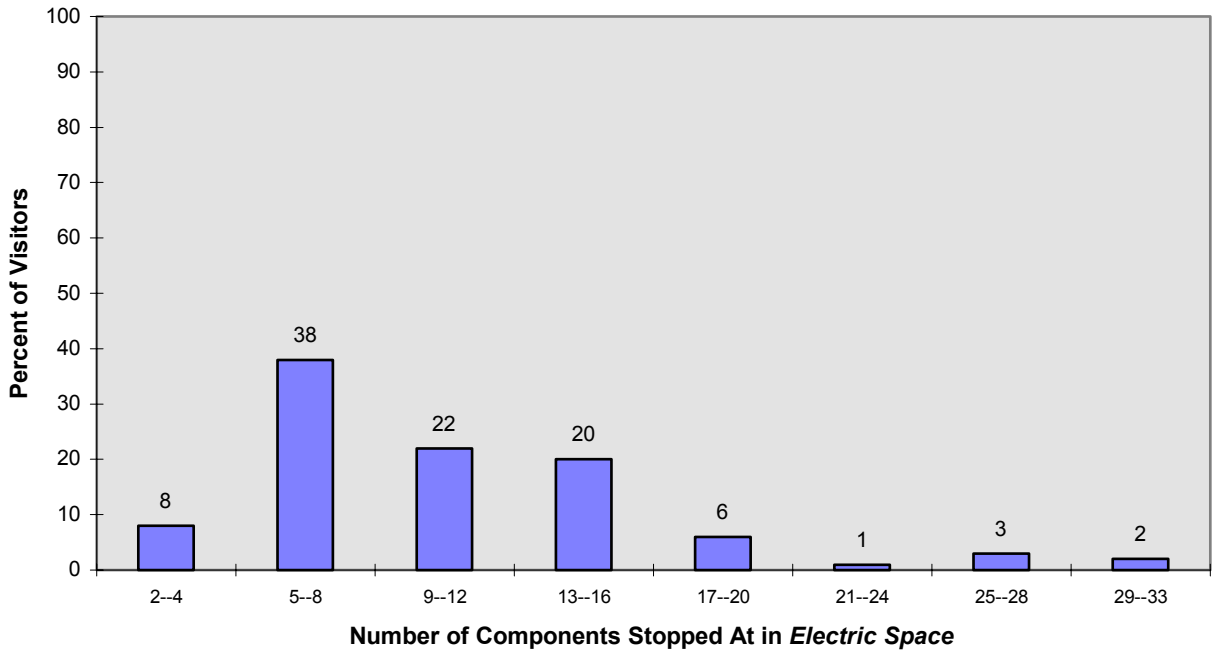
Overall Visiting Patterns in the Exhibition

Total Number of Components Stopped At per Visitor

One measure of gauging the visitor experience in an exhibition is to count the stops visitors make. For the purposes of this study, a "stop" was defined as a visitor standing for 3 seconds or longer in front of a given component. If a visitor returned to a component at which she or he had previously stopped, it was not counted as an additional stop but the amount of time spent was included in the total time spent at the component.

Figure I.1 shows that visitors to *Electric Space* stopped at between 2 and 33 different components of the 65 or 66[1] available. Over three-quarters of visitors (80 percent) stopped at between 5 and 16 components (i.e., from 8 percent to 25 percent of the exhibition). Few visitors (6 percent) stopped at more than 20 components (i.e., one-third of the exhibition), and no visitor stopped at more than half of the components. The median number of stops in *Electric Space* was 9.0 (not shown in figure).

Figure I.1.
Number of Components Stopped At per Visitor



[1] There were 65 components available in the installation at VASC, and 66 available at MSC.

To determine whether the number of components stopped at was associated with gender, visitor group composition, or exhibition site, a series of *t*-tests were computed. From the analysis emerged one statistically significant relationship: visitors at VASC stopped at more components than did visitors at MSC (see Table I.3).

Table I.3.
Number of Components Stopped At per Visitor by Site

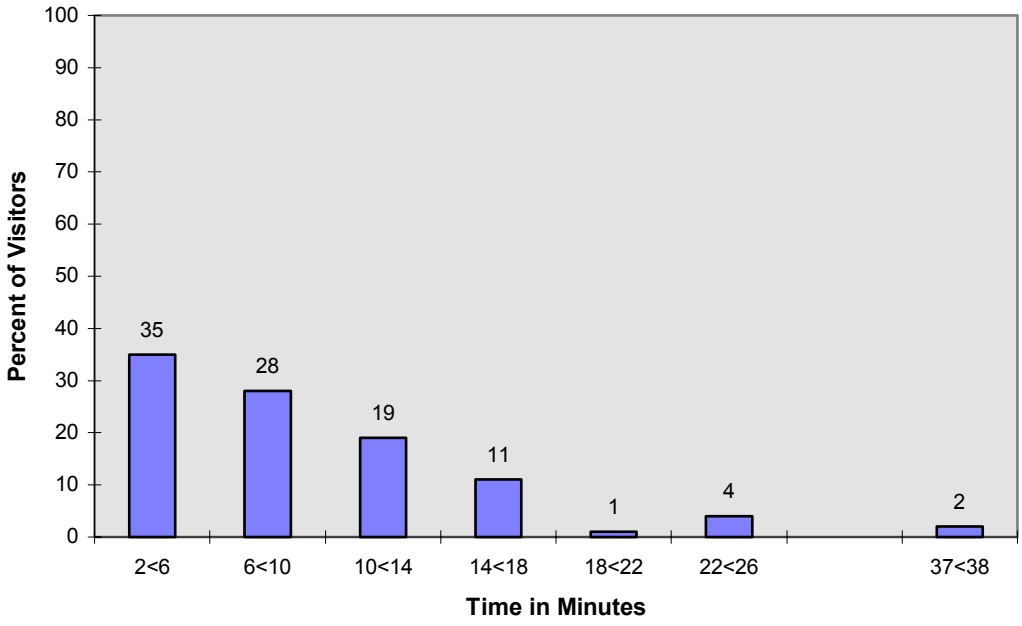
Exhibition Site	Mean No. of Components	Standard Deviation
VASC	12.4	6.7
MSC	9.7	5.5

t-value = 2.12, df = 98, $p = 0.036$

Total Time (in Minutes) Spent in Exhibition

Another way to look at the visitor experience in an exhibition is to examine how much time people spend there. Figure I.2 presents the amount of time visitors spent in *Electric Space*. The shortest amount of time spent in the exhibition was 2.05 minutes, and the longest was 37.62 minutes. Nearly two-thirds of visitors spent less than 10 minutes in the exhibition (63 percent). The median amount of time spent was 8.13 minutes (not shown in figure).

Figure I.2.
Total Time Spent in *Electric Space*



T-tests were calculated on these data also, to determine whether gender, visitor group composition, or site was associated with time spent in the exhibition. Again, one relationship was statistically significant: visitors at VASC spent a longer time in *Electric Space* than did visitors at MSC (see Table I.4).

Table I.4.
Time Spent in *Electric Space* by Site

Exhibition Site	Mean Time (in Minutes)	Standard Deviation
VASC	12.8	8.7
MSC	7.8	4.3

t-value = 3.20, df = 43.08, $p = 0.003$

Stops at Exhibition Components

Exhibitions are free-choice environments. Most visitors do not follow a linear path through an exhibition but are drawn from one component to another according to what attracts or interests them. Tallying where visitors stop gives exhibition teams a sense of the varied attracting power of individual components. As data presented in the previous section indicate, most visitors to *Electric Space* stopped at relatively few components of all those available. Hence, the stops they did make determined their experience in the exhibition.

In this section of the report, components are analyzed individually and by type. For the purpose of this analysis, the components in *Electric Space* were classified as one of the following four component types: interactives, videos, text panels, and quotation panels.

Individual Components

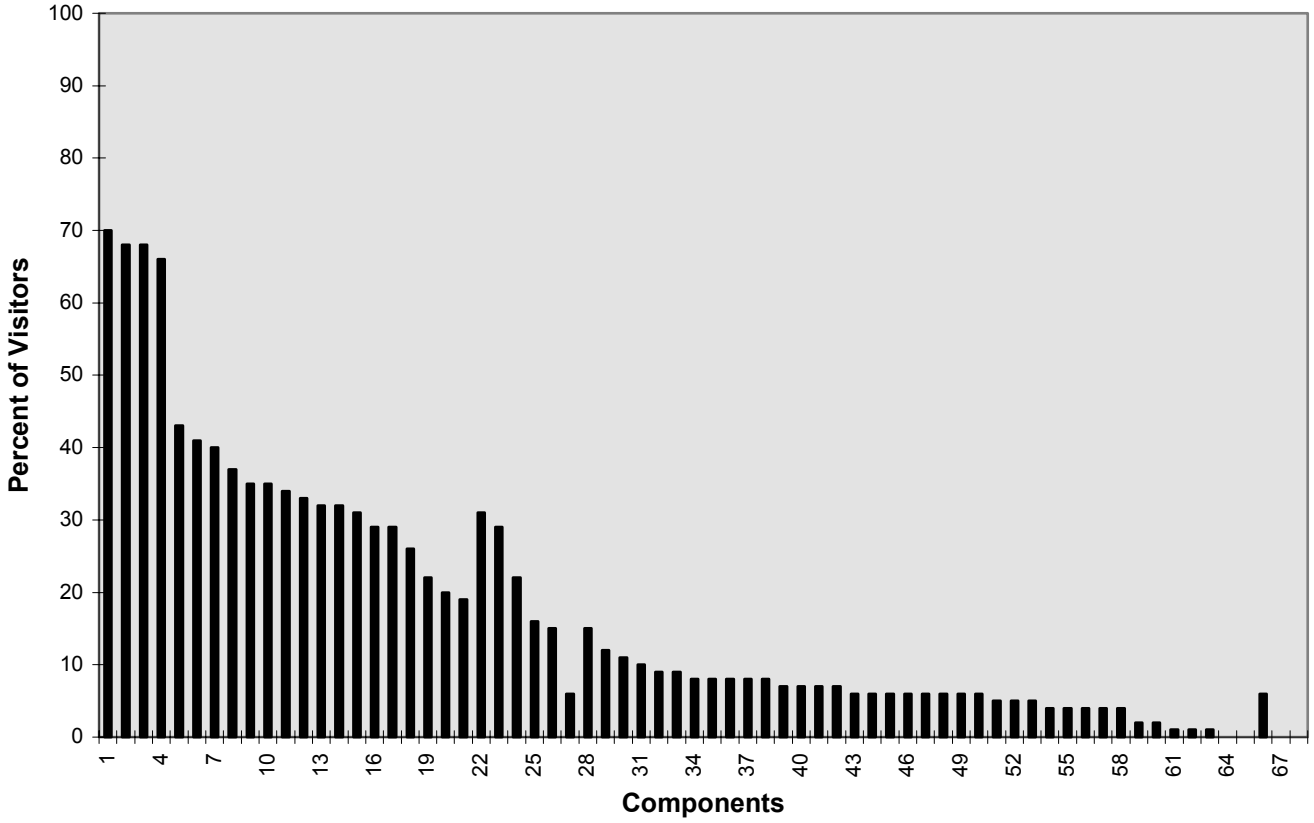
Figure I.3 presents the visitation at each of the 68 different components in *Electric Space*. In this figure each component has its own bar but only every third component is numbered. Components numbered 1 through 21 are interactives, those numbered 22 through 27 are videos, those numbered 28 through 65 are text panels, and those numbered 66 through 68 are quotation panels. (See Appendix C for a complete listing of the names of the numbered components included within each type.) Within each component type, the individual components are numbered according to decreasing percentages of visitors who stopped. If more than one component attracted the same percentage of visitors, the components were ordered according to decreasing median time spent by visitors at the component.

Figure I.3 shows that interactives, as a group, attracted a higher percentage of visitors than did videos. Likewise, videos, as a group, attracted a higher percentage of visitors than did text panels. Across all components, the number of visitors who stopped ranged from 0 to 70.

Only four components were stopped at by over half of visitors: Four States of Matter, Kinetic Theory, Red Plasmasphere, and Bar Magnet & Compasses. In fact, all of the components that were stopped at by over one-third of visitors were interactives. The two most frequently stopped at videos attracted over one-quarter of visitors. The most stopped at text panel attracted 15 percent of visitors. Only four components were never stopped at by visitors—two text panels: Magnetic Fields and Man & Sun/Studying the Sun and two quotation panels: Auden and Eliot.

Each of the component types is examined separately below.

Figure I.3.
Electric Space **Components at Which Visitors Stopped**



Component Types

The relative attracting power of the various component types can be measured by comparing the number of stops visitors made and the time they spent at each type. Table I.5 lists the median stops and median number of seconds spent at each component type in *Electric Space*. In general, visitors stopped at more interactives than videos, text panels, or quotation panels. Whereas the median number of stops at interactives was 6.0, the median stops at both videos and text panels was 1.0. The fact that visitors were equally likely to stop at a video as they were to stop at a text panel is especially interesting considering there were six times as many text panels as videos available in the exhibition.

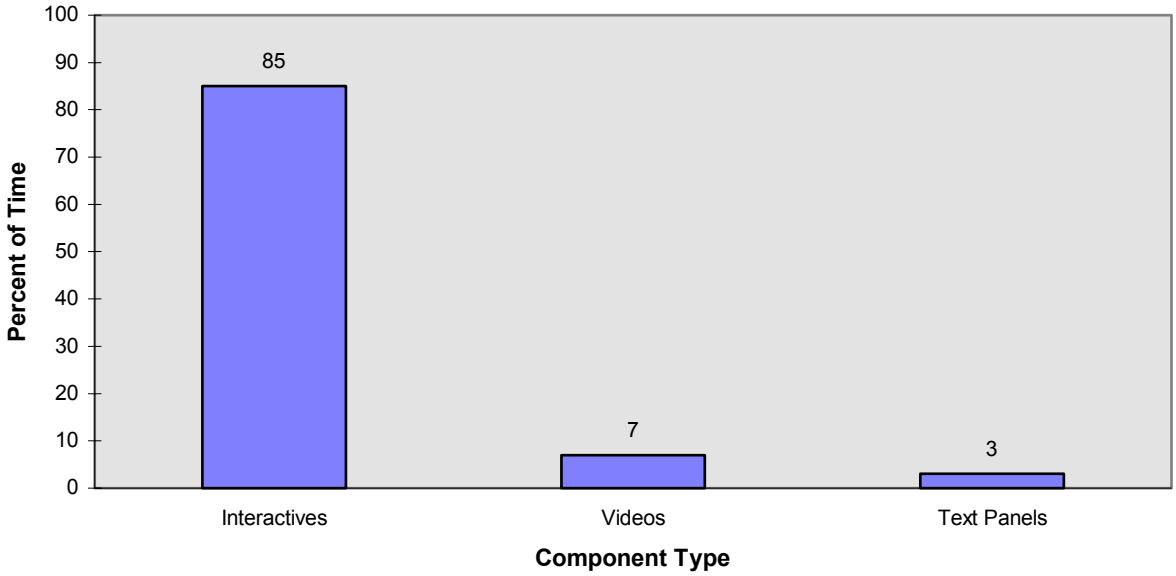
Table I.5.
Median Number of Stops and Median Time Spent at Component Types

Component Type	Total Components	Median Stops[1]	Median Time (in sec)[2]	Median % of Time[3]
Interactives	18–19[4]	6.0	263.0	84.6
Videos	6	1.0	40.0	7.4
Text panels	38	1.0	42.0	3.4
Quotation panels	3	.0	22.5	.0

[1]*Median stops* includes all 100 tracked visitors.
[2]*Median time* includes only those visitors who stopped at the component type.
[3]*Median percent of time* includes all 100 tracked visitors.
[4]There were 18 interactive components available at VASC and 19 available at MSC.

In keeping with the greater number of stops at interactives, visitors also spent more time at interactives than at any other component. The median percent of time that visitors spent at interactives while in *Electric Space* was 85 percent (see Figure I.4). In comparison, visitors spent a median of 7 percent of their time watching videos and 3 percent looking at text panels. (Quotation panels are not included in Figure I.4, because there were only three of them in the exhibition and only one was stopped at by a few visitors.)

Figure I.4.
Percent of Time Spent at Each Component Type



Interactives

Interactive components were the most frequently stopped at component type in *Electric Space*. Every visitor stopped at one or more interactives while in the exhibition. As Figure I.5 shows, visitors stopped at between 1 and 16 of the exhibition's 18 or 19[2] interactive components. Close to half of visitors stopped at more than 6 interactives (46 percent).

Figure I.5.
Number of Interactives Stopped At per Visitor

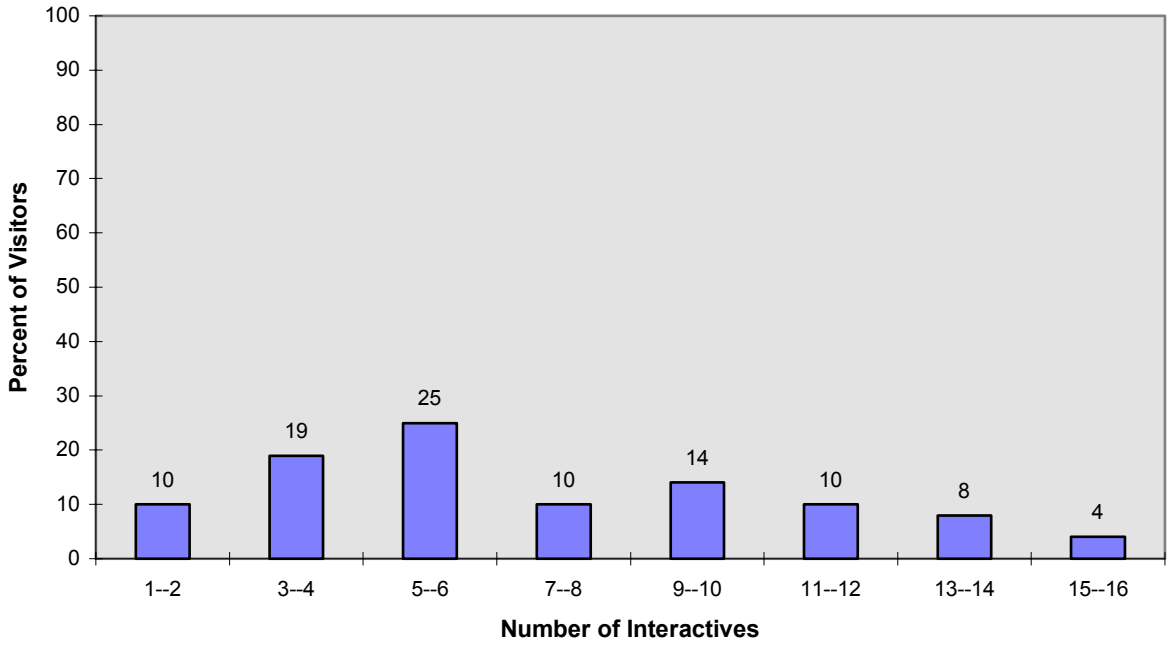


Table I.6 lists the percentage of visitors who stopped at each interactive component in rank order. Five components were available or were included in the observations at only one site. For these components the percentage of visitors who stopped was calculated based only on the sample at the respective site. For instance, Kinetic Theory was available only at MSC, and 44 of the 65 visitors tracked stopped at it. Therefore, in Table I.6 the percentage of visitors stopping at Kinetic Theory is 68 percent.

[2] There were 18 interactive components available at VASC and 19 available at MSC.

Table I.6.
Percent of Visitors Who Stopped and the Median Time They Spent at Each Interactive

Interactive	% of Visitors	Median Time (in Sec)	Interactive	% of Visitors	Median Time (in Sec)
1. Four States of Matter	70	53.5	12. Color Rendering	33	23.0
3. Kinetic Theory[1]	68	31.5	13. Electromagnet	32	27.0
2. Red Plasmasphere	68	29.0	14. Violet Plasmasphere[4]	32	21.0
4. Bar Magnet & Compasses[2]	66	33.0	15. Plasma & Planetary Noises	31	31.0
5. Geiger Counter	43	40.0	16. Terrella[5]	29	46.0
6. Emission Spectra from Stars	41	52.0	17. Oerstead's Experiment	29	20.0
7. Magnetic Fields	40	40.0	18. Half-Frosted Fluorescent Tube	26	20.5
8. Radio Interference— Headphones[3]	37	35.0	19. Radio Interference—Phone	22	20.5
9. Rice University CD-ROMs	35	94.0	20. CRT with Magnet	20	30.0
10. Solar Sprinkler Spirograph	35	44.0	21. Magnetic Attraction/Repulsion[6]	19	34.0
11. 3-D Magnetic Fields	34	22.0			

[1]Not available at VASC. [2]Not included in the trackings at MSC because it was located outside of the exhibition. [3]Not available at MSC; not working at VASC.
[4]Not included in the trackings at VASC because it was located away from the exhibition. [5]Not working at VASC. [6]Not available at VASC.

As listed in Table I.6, the interactive at which the most visitors stopped was Four States of Matter (70 percent), followed closely by Kinetic Theory, the Red Plasmasphere (68 percent in each case) and Bar Magnet & Compasses (66 percent). The Geiger Counter, Emission Spectra from Stars, and Magnetic Fields were also highly visited components (43 percent, 41 percent, and 40 percent, respectively). The three least visited interactives were Magnetic Attraction/ Repulsion, CRT with Magnet, and the Radio Interference Phone (19 percent, 20 percent, and 22 percent, respectively).

Table I.6 also lists the median time spent by visitors at each interactive. The interactive that held visitors' attention for the longest time was the Rice University CD-ROMs, at which the median time visitors spent was about 1.5 minutes. The next two highest median times were spent at Four States of Matter and Emission Spectra from Stars (53.5 seconds and 52 seconds, respectively).

To determine whether the amount of time that visitors spent at interactives was associated with gender, group composition, or exhibition site, *t*-tests were calculated. Results showed that one relationship was statistically significant. Visitors at VASC stayed longer at *Electric Space* interactives than did visitors at MSC (see Table I.7).

Table I.7.
Time Spent at Interactives by Site

Exhibition Site	Mean Time (in Minutes)	Standard Deviation
VASC	7.9	6.8
MSC	4.2	3.0

t-value = 3.03, df = 41.17, $p = 0.004$

Videos

Electric Space offered visitors the opportunity to view six videos. As shown in Figure I.6, nearly three-quarters of visitors stopped at one or more videos (72 percent). Table I.8 lists the percentage of visitors who stopped at each video in descending rank order. The most frequently stopped at video was Space Weather (31 percent), followed by Auroras (29 percent). The least visited video was X-rays from the Sun, stopped at by only 6 visitors.

Figure I.6.
Number of Videos Stopped At per Visitor

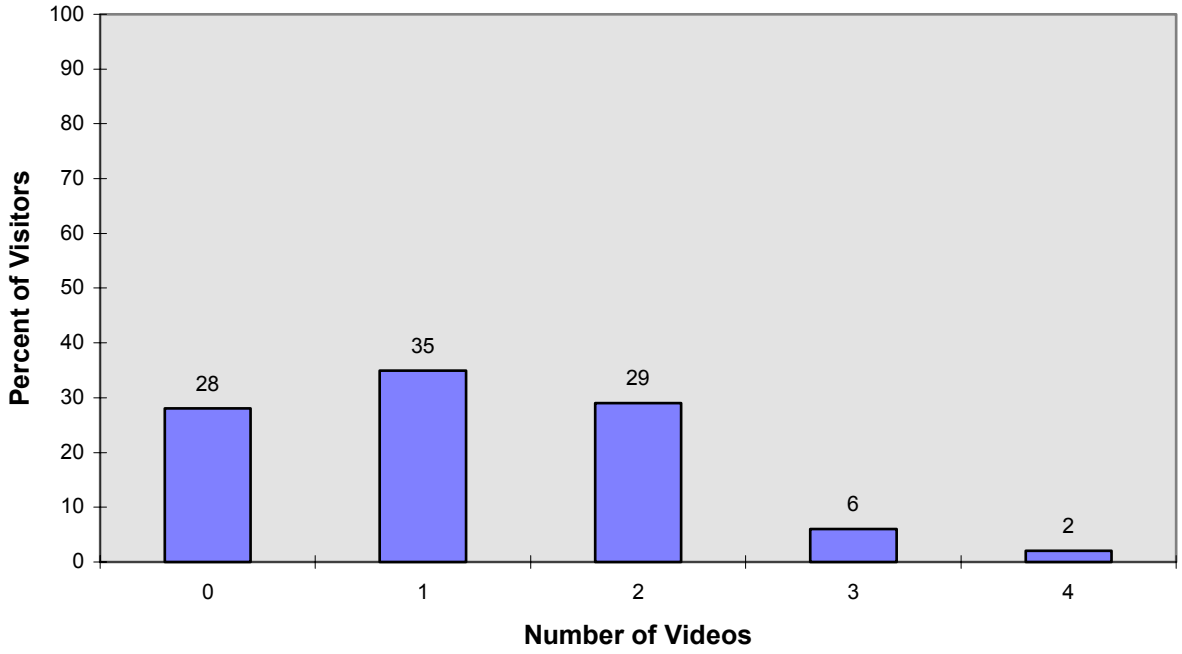


Table I.8.
Number of Visitors Who Stopped and the Median Time They Spent at Each Video

Video	% of Visitors	Median Time (in Sec)
22. Space Weather (with phone)	31	27.0
23. Auroras	29	44.0
24. Star Trek Plasma (with phone)	22	17.0
25. Mysterious Lights	16	24.5
26. The Changing Sun	15	22.0
27. X-rays from the Sun	6	27.0

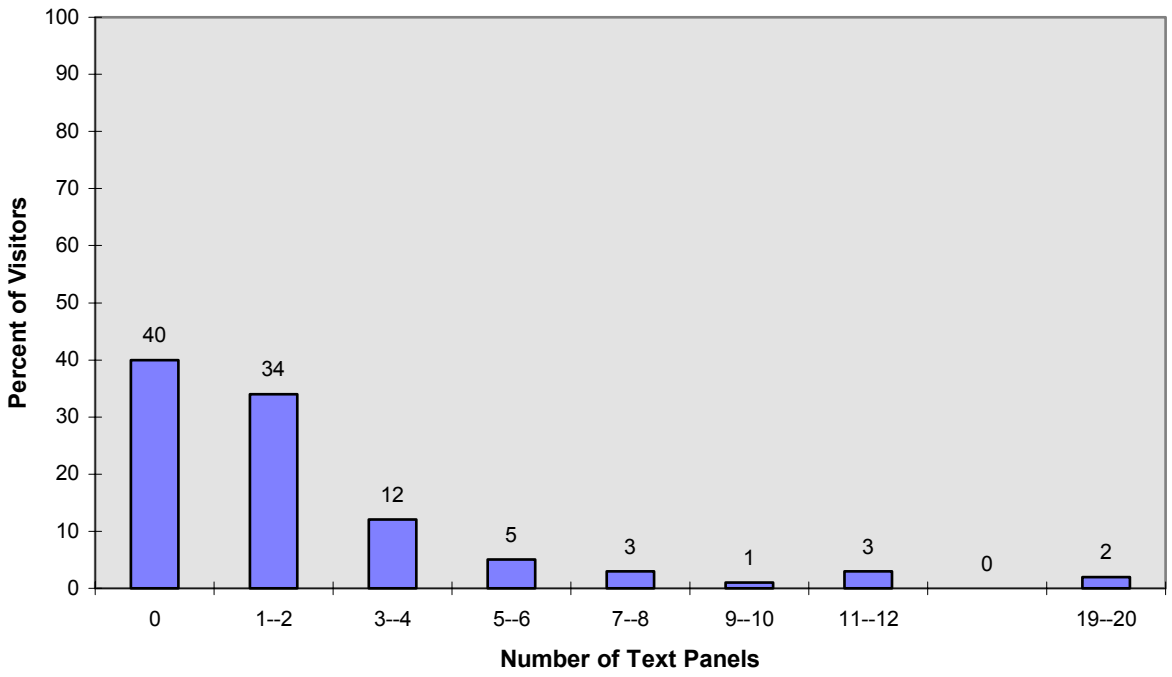
Table I.8 also lists the median amount of time that visitors watched each video. The video that held visitors' attention the longest was Auroras, which was watched for a median of 44 seconds. In contrast, visitors spent the least amount of time watching the Star Trek video (median = 17 seconds).

T-tests were computed to determine whether time spent viewing videos was associated with gender, visitor group composition, or exhibition site. No differences appeared among the various audience segments.

Text Panels

Electric Space presented visitors with 38 text panels. As displayed in Figure I.7, two-fifths of visitors did not stop at any of them (40 percent). One-third of visitors stopped at one or two text panels (34 percent). Only two visitors stopped at more than one-third of the exhibition's text panels.

Figure I.7.
Number of Text Panels Stopped At per Visitor



Listed in Table I.9, in rank order, are all of the text panels along with the number of visitors who stopped at them. The most looked at text panel was Sun/What Is a Plasma? (15 percent of visitors stopped). Man on the Moon/Killer Radiation, Earth's Magnetosphere/Space Weather, and Las Vegas/ States of Matter were the next most looked at text panels (12 percent, 11 percent, and 10 percent, respectively).

Table I.9.
Number of Visitors Who Stopped and the Median Time They Spent at Each Text Panel

Text Panel	% of Visitors	Median Time (in Sec)	Text Panel	% of Visitors	Median Time (in Sec)
28. Sun/What Is a Plasma?	15	29.0	46. Heliosphere	6	24.0
29. Man on the Moon/Killer Radiation	12	18.5	47. Cactus/Entering Electric Space	6	22.5
30. Earth's Magnetosphere/Space Weather	11	29.0	48. Solar Flares	6	19.0
			49. Earth's Light Show	6	15.5
31. Las Vegas/States of Matter	10	9.0	50. Spacecraft/Our Space Laboratory	6	12.0
32. Northern Lights/Space Weather	9	26.0	51. Planets/The Planets' Magnetospheres	5	46.0
33. Sun in HAlpha/Electromagnetic Sun	9	16.0	52. Stars/Cosmic Connection	5	25.0
34. Nebula/Space Is Not Empty	8	26.0	53. Our Dynamic Sun	5	11.0
35. Plasmas on Earth	8	25.5	54. Sun's Structure	4	23.5
36. Satellite/The First Discovery of the Space Age	8	21.5	55. Corona Hole/The Solar Wind	4	15.5
			56. Aurora with Spacecraft/ Ionosphere	4	15.5
37. Aurora/Auroras in History	8	10.0	57. Radio Sun/Ionosphere & Your Radio	4	14.0
38. Magnets and Electrons	8	9.5	58. How's the Weather	4	6.0
39. The Making of a Plasma	7	19.0	59. Dying Stars/An Electric Universe	2	37.5
40. Corona	7	18.0	60. Magnetic Clouds/Solar Disturbances	2	17.0
41. Galaxy of Bubbles/Magnetic Bubbles	7	11.0	61. Horseshoe/Magnetism	1	55.0
42. Comet/Magnetic Earth	7	8.0	62. Electrical Storm/Magnets & Electricity	1	52.0
43. Aurora/Astronauts See the Aurora from Space	6	30.0	63. Acknowledgments	1	16.0
			64. Magnetic Fields	0	.0
44. The Aurora	6	27.0	65. Man & Sun/Studying the Sun	0	.0
45. Sunspots	6	25.5			

Table I.9 also lists the median amount of time that visitors spent looking at the individual text panels. The panels that held visitors the longest appear to be Horseshoe/Magnetism and Electrical Storm/Magnets & Electricity (55 seconds and 52 seconds, respectively). However, because these panels were looked at by only one person, the median time may represent more of an extreme case than an average tendency. Among the panels that were viewed by more than one visitor, Planets/The Planets' Magnetospheres was looked at for the longest median time (46 seconds). Of course, from observational data, it is difficult to know *why* visitors stayed a relatively long time at this particular panel.

To test whether gender, visitor group composition, or exhibition site was associated with the amount of time visitors spent looking at text panels, *t*-tests were conducted. Results showed that visitors without children spent more time and a higher percentage of their time in *Electric Space* looking at text panels than did visitors with children (see Table I.10).

Table I.10.
Time Spent at Text Panels as a Function of Visitor Group Composition

Visitor Group Composition	Mean Time (in Minutes)[1]	Standard Deviation	Mean % of Time[2]	Standard Deviation
Without children	2.1	2.5	16.3	21.6
With children	0.8	0.9	8.2	16.1

[1] t-value = 2.66, df = 33.78, p = 0.012; [2] t-value = 2.09, df = 79.68, p = 0.040

Quotation Panels

There were three quotation panels presented in *Electric Space*, but practically no visitors stopped at any of them. As shown in Table I.11, only the panel with the quotation by Einstein was stopped at by any visitors. Of the six visitors who stopped to look at the Einstein quote, the median time they spent was 22.5 seconds.

Table I.11.
Number of Visitors Who Stopped and the Median Time They Spent at Each Quotation Panel

Quotation Panel	% of Visitors	Median Time (in Sec)
Einstein	6.0	22.5
Auden	.0	.0
Eliot	.0	.0

T-tests revealed no differences among audience segments regarding the time they spent looking at quotation panels.

II. OPEN-ENDED INTERVIEWS

A total of 55 interviews were conducted with visitors to *Electric Space.* At the Virginia Air & Space Center (VASC), 29 interviews were conducted in December 1996. Of 38 individuals approached, 9 declined to be interviewed. Thus, the refusal rate at VASC was 23.7 percent, a rate typical of museum surveys. At the Maryland Science Center (MSC), 26 interviews were conducted in April 1997. Of the 47 visitors approached, 21 refused to participate; thus, the refusal rate at MSC was quite high, at 44.7 percent. This high refusal rate appears to be the result of two factors associated with the exhibition environment. First, many visitors merely passed through *Electric Space* on their way to the planetarium or in their effort to locate the Demonstration Stage. When these visitors were approached by the interviewer, they declined because they were actually on their way elsewhere and had not paid much attention to *Electric Space.* Likewise, many visitors at MSC were holding tickets for the IMAX theater. When they were approached, they indicated that they did not have adequate time, because they needed to arrive at the theater for their scheduled show.

At each site, the gender, age, and ethnicity of those who refused to participate were no different from those of the interviewees. Of the 55 interviews that were conducted, 2 from each site were excluded from analysis for the following reasons: one visitor did not answer the interview questions directly, another indicated at the conclusion of her interview that her experience of *Electric Space* was distorted because she was ill, a foreign visitor appeared to have difficulty understanding some English, and another interviewee elicited responses from a companion. Hence, the following analysis is based on 51 substantive interviews.

Visitor Characteristics

As Table II.1 shows, of the 51 interviewees who were considered in this analysis, nearly two-thirds were male (61 percent), and over one-third were female (39 percent). Half of interviewees were under the age of 35 (53 percent), and practically all were white (86 percent).

Table II.1.
Demographic Characteristics in Percent

Characteristic	VASC %	MSC %	Total %
Gender			
Male	74.1	45.8	60.8
Female	25.9	54.2	39.2
Age			
16 – 24	18.5	33.3	25.5
25 – 34	33.3	20.8	27.5
35 – 44	37.0	25.0	31.4
45 – 54	7.4	16.7	11.8
55+	3.7	4.2	3.9
Ethnicity			
Caucasian	77.8	95.8	86.3
African American	7.4	4.2	5.9
Asian American	7.4	.0	3.9
Hispanic/Latino	3.7	.0	2.0
Other	3.7	.0	2.0

Visitors' Perceptions of Electric Space

The initial interview question was essentially an ice-breaker, helping visitors to focus on the exhibition of interest (i.e., *Electric Space*) and to feel comfortable with the interviewer. Interviewees were asked, "What would you say this exhibition is about?" Many responses to this request came in the form of lists of topics, rather than coherent sentences.

As listed in Table II.2, half of interviewees referred to electromagnetic (or magnetic) fields or forces, magnets, magnetism, or the magnetosphere. Nearly half mentioned electricity, electronics, or electric space. One-third included plasma in their responses. Space, the sun or solar activity, and states of matter were each topics noted by one-fifth of interviewees. Only one visitor did not provide a relevant response.

Table II.2.
Visitors' Perceptions of What *Electric Space* Is About in Percent

Topic Included in Visitor Response	%
Electromagnetic (or magnetic) fields or forces, magnets, magnetism, or the magnetosphere	54
Electricity, electronics, electric space	42
Plasma	36
Space	20
Sun, solar activity, solar winds, sun's energy	20
States of matter, matter, gasses	18
Auroras, northern lights	12
Effects on humans (e.g., communications)	10
Forces in space, forces of gravity, energy	10
Science	10
Radiation, radioactive materials	6

Visitors' Understanding of Space

The second interview question asked visitors, "In what ways, if any, did this exhibit change what you know about space?" Nearly half of interviewees indicated that *Electric Space* did not change what they already knew. The reasoning associated with their responses, however, varied greatly. Many interviewees suggested that they already knew a lot about space and so the information in the exhibition was not new (see quotation 1 below). A few others clarified that while the exhibition did not *change* what they knew, it *added* to what they knew (see quotation 2). Others admitted that *Electric Space* did not change what they knew because they did not read much of the text (see quotations 3 and 4). One individual noted that because he did not "know a whole lot about space," the exhibition could not *change* his understanding. Another claimed that his knowledge about space did not change because the exhibition was "too vague" and had "no flow," so he "couldn't follow it."

> Very little. I've been in this business for 40 years, from the engineering point of view. (1)

> It didn't change anything that I already knew, it just expounded on what I had already known and learned in class. (2)

> No way. . . . We didn't read a whole lot about it. They're a little too young for reading all this. They want to run from thing to thing. (3)

> I don't think it really did because I didn't spend enough time to read each of the things. I think it would if you spent the time to read it. I think it would really be – what is the word I'm looking for – educational. I tried to avoid that part of it! (4)

The remainder of the response categories refer to topics about which interviewees indicated they learned. One-quarter of interviewees encountered new knowledge about plasma (see quotations 1 and 2 below). Some individuals were introduced to activities associated with the sun, for instance, solar winds and storms (see quotation 3). Others learned about auroras, specifically the northern lights (see quotation 4).

> To be honest with you, I never knew there was a fourth state of matter: plasma. I mean, right at that fundamental level, that's a significant addition to what I know about the world. (1)

> I didn't know plasma gas ran fluorescent lights, for some reason. I knew it was a gas, but, it's plasma gas in fluorescent lights. And [it] really sends an ultraviolet radiation. I always wondered why you didn't want to break fluorescent lights. I was always like, why? I knew there was a gas in there, but I didn't know what kind of gas, and I learned that today. (2)

> I learned about the sun, more than I knew about the sun. . . . Such as different storms that the sun can cause and the effects of those storms on earth living. (3)

> I suppose the only thing really is the northern lights, in [regards to] which I looked at the exhibits over there. Talked about how some of the winds in space can sort of collide with the top of the earth's atmosphere to create the northern lights. (4)

A few interviewees noted their increased understanding of magnetic fields (see quotation 1 below). Others came to recognize that space is not empty as they had previously believed (see quotations 2 and 3).

> I guess the one thing I got was the idea of looking at magnetic fields, the magnesia surrounding earth and other planets, as objects, that there are particles there rather than just fields. That these have actual sizes and you can look at them, maybe not in the visible range, but . . . that they're there and you can test their presence. And I guess I knew that, but it focused more on that these are boundary conditions from seeing it in space to on earth and what's happening is important. (1)

> Well there's a lot more in space that I did not imagine. The different materials in space, the gasses, the liquids. It's much more complex. (2)

> I'd say mostly that it's more composed of charged particles than most people think. Most people think there's nothing there, it's just a vacuum. . . . 'Cause I thought it was pretty much empty. Just a blank space. (3)

Three individuals learned about gasses, and, of course, there were a few idiosyncratic responses. For example, one interviewee learned about electricity; another found out that "the earth is expanding." One visitor learned about interference on radios and was surprised to find that "the ancient Chinese people had the tools to look at the sun 2,000 years ago." One interviewee spoke about research into climates, habitation, and "living on a planet," whereas another thought *Electric Space* showed "what's out there," such as other solar systems, and "what the whole universe is about."

Visitors' Understanding of Electric Space *Concepts*

To gauge visitors' understanding of concepts presented in *Electric Space*, interviewees were shown a list of ten topics and asked which they could comfortably discuss. Table II.3 lists the ten topic options and the percentage of visitors who talked about each. Interviewees were invited to talk about as many topics as they wanted up to three. Their responses ranged from a brief phrase to a relatively extensive discourse. Of course, within some responses, it is impossible to determine what parts were gathered from the exhibition and what came from the visitor's prior knowledge.

Table II.3.
Exhibition Topics Discussed by Visitors in Percent

Exhibition Topic	%
Magnetic Fields	31
States of Matter	29
Sun	27
Plasma	25
Radiation	24
Aurora (northern lights/southern lights)	22
Interplanetary Space	6
Heliosphere	4
Space Weather	4
Earth's Atmosphere	2
No relevant response	18

Six of the topics were frequently discussed by visitors: magnetic fields, states of matter, the sun, plasma, radiation, and auroras. Sample responses for each topic are printed below to provide a sense of the visitors' own words.

Magnetic Fields

Magnetic fields, how the earth's got two axes, north and south poles, and the magnetic fields are affected by the sun and that affects the earth as a whole as far as compasses go and stuff like that.

Magnetic fields. Obviously every magnet sets up a field with a pattern of energy around it and that constitutes the field, and any iron filings, for example, when you play with them in this exhibition, they show you which way the field is oriented. And also the intensity of the field in any given distance of the magnet, distance and bearing of the magnet.

Electric currents can cause magnetic fields. The earth has magnetic fields which is caused a lot by the rotation of the earth.

States of Matter

I guess states of matter. There's four of them: solids, liquids, gas, plasma. . . . If you dropped the temperature way down it would become solid, as you increase the temperature and the molecules and atoms vibrate more they break free and they flow as a liquid. Heat it even more, you have a gas, your molecules are spaced further apart. If you continue to heat it you get to a point where charges break away, electrons start breaking away from the nucleus and you get what's called plasma.

Probably the states of matter. You have the solids, liquids, gasses, and there's one more. I can't think of it.

States of matter. There are four states of matter. Three of them, solid, liquid and gas are very common on earth. The fourth one, plasma, is very much like a gas, but it doesn't have a definite shape or volume, but because the electrons and protons get separated or the electrons become ionized because of the great heat or radiation, you have individual charges which can travel easily, so plasma conducts electricity.

Sun

Let's go to the sun. . . . It's a big star, or puts out lots of energy and heat. It's got sunspots that repeat cycles every eleven years. It's basically a type of a nuclear reactor that puts out power.

The sun. How the sun is always exploding, it's a star. How it lets out gamma rays, X-rays, and then the ultra-violet rays.

How about the sun. It's a star. Our planet goes around it.

Plasma

> Plasma is a fourth state of matter, it's not a solid, liquid or a gas. I got the idea from the display that it's superheated material up there past the gaseous stage. But then, I could of sworn somewhere in the display it still referred to it as a plasma gas. So I'm a little confused, is it a gas or something other than a gas? And then if it's superheated, how can it exist in the super-cold of space? So I'm confused by that.
>
> Plasma, and that it comes off of the sun, brought here by the wind. That water can become plasma if it reaches fifteen hundred degrees.
>
> The plasma, what I learned about that is that it's just a basically heated up gas. Something that we don't see much on earth, except for in flames or in neon lights, etc. But that [it] is like water is to earth, plasma is to space.

Radiation

> There's solar radiation, and there are examples of radioactive materials with a Geiger counter, which I thought was very helpful for the little kids, explaining [that] radiation comes from the breakdown of atoms and the release of electrons.
>
> Maybe radiation. It comes from the sun. Exposure to it can be hazardous. A Geiger counter picks up radiation, I saw a sample of that in the exhibition. I thought I saw something that when the sun causes certain storms, it can be dangerous to astronauts. It can cause radiation exposure to astronauts.

Aurora

> Specifically from this exhibition, I spent a lot of time with the Aurora exhibition. They have a computer screen and the Aurora are the Northern Lights [that] come out of Alaska and they result from the solar wind, from the sun hitting the earth and its magnetic field and, therefore, creating these bursts of light.
>
> The Aurora. It was interesting to see that back in the year 1000 the Vikings thought that it was the spirits fighting with a walrus head.

Few interviewees chose to talk about four of the topics listed: interplanetary space, space weather, heliosphere, and earth's atmosphere. Nearly one-fifth of interviewees did not feel comfortable speaking about any of the topics listed, or could recount only terms or interactives without suggesting any meaning, or provided responses irrelevant to the question asked.

Hands-on Activities

To assess the mechanical success of the interactive components, interviewees were asked whether they had trouble using any of the hands-on activities. Four-fifths of visitors responded that they had no trouble using the interactives, though a few admitted that they did not use many of them.

> I liked them, the instructions and stuff on it were pretty good. (And do you have any suggestions on how to make them any easier to use?) Basically no, I mean, it tells you what to do, push a button, and it's simple, easy to follow.
>
> I thought they were all very easy to use. There were instructions on them. The plates [text] on them were very explicit, and if you can like count from one to two to three to four, you can pretty well handle it.
>
> They were easy enough; my son being eleven, he just immediately went to operating them, and he didn't have any difficulty at all, so that worked out real well.
>
> I actually thought they worked very well, the instructions were excellent and simple.

In contrast, one-fifth of interviewees reported having difficulties using the interactives. Two individuals had trouble understanding what to expect from the plasmasphere (see quotation 1 below). One visitor had difficulty with the computer touch-pad; another believed the Emission Spectra from Stars was not working because his children could not see anything. One individual found the Bar Magnet & Compasses and the Four States of Matter confusing (see quotation 2); another did not understand Color Rendering and could not find the "buttons" referred to in the interpretive text. Lastly, one interviewee explained the problems he encountered in his attempts to use the Solar Sprinkler Spirograph and the Electromagnet (see quotation 3).

> Some of them were broken. Some of them, if they were working, the instructions weren't clear enough as far as what you should expect to see. . . . Like the plasma one [plasmasphere], I wasn't sure what they were. . . . It's like, well if it's supposed to be doing that, it's broke. It's not doin', it's just sitting there. (1)
>
> Some of them were a little complicated. . . . [For instance,] the one that asks you if you can find the magnetic fields on earth. Like, for example, I heard that a meteor landed somewhere on Canada and that's supposed to be where the magnetic field is, 'cause the compasses all face that way, right? But they tell you to look for it with that little gadget, but I couldn't find it. (Okay, and was there another one you thought was difficult?) The part where they have the three spheres, the liquid one, the gas one, and well the signs below it were actually not in front of the spheres, so it was kind of confusing. (2)
>
> The one where you put the pencil in the thing and spin the paper around. . . . It's tough to spin it with one hand and move the pencil with the other hand. It's really a two-person exhibit. . . . [On] the electromagnet there was no handle to try to pick it up and see how heavy it was without it. If I pushed the button, pushed the metal rod inside and tried to hold it there I was going to get my fingers caught in the top. (So, do you have any recommendations on what might make those easier to use?) Well, for the electromagnet one, just have a handle at the top, or a rope or something, so you can try to pull it up first. And for the other one, either have the handle connected to the pencil so the pencil moves in a straight line from the center automatically, or state explicitly on it [that] it's a two-

> person thing. One person [to] move the pencil from the center out . . . and have the other person spin it. (3)

In addition, one-fifth of interviewees, primarily at VASC, whether or not they reported having trouble, noted that certain interactives were not working or were missing pieces. A few visitors at VASC mentioned that the Terrella was "broken" (see quotations 1 and 2 below). Other VASC visitors referred to the broken Shortwave Radio Headphones (see quotation 3). The fact that the Solar Sprinkler Spirograph was missing pieces was noted at both sites (see quotation 4).

> The one with the aurora and the ball, the magnetic part. . . didn't seem to work. I don't know what it was supposed to do. . . . I think there were maybe three or four that didn't seem to work properly. (1)

> The big one you've got of the earth that shows the aurora on the bottom of it. I don't know what the point is of the magnetic field button. . . . You push the button and can't see anything. I don't think it's working right. (2)

> Actually a lot of them are rather confusing. I didn't really get the point of them. [For instance,] the radio interference one. I put the headset on, there was nothing on the headset. I picked the phone up, I guess that's what they were trying to show you, they said put the headset on and not pick the phone up. (3)

> Probably the only one was . . . where you were drawing circles on that turntable. It said something about make a sun or stamp a sun. Apparently the stamp's missing. (4)

One-third of interviewees shared their experiences or offered suggestions to improve the interactive components. For example, a few visitors noted the slow response time of the interactives, referring to their expectation for a more "immediate effect." Others suggested presenting instructions through graphics or audio rather than text. (See Appendix D for a complete list of visitors' suggestions.)

Exhibition Text

Interviewees were next asked whether they had any trouble reading any of the labels. Most interviewees initially referred to the interactives' instructional text and had to be prompted to discuss the wall panels. Regardless of which text they referred to, practically all of the interviewees indicated that they had no trouble reading it.

Some referred to the conciseness of the text and its nontechnical terminology; others referred to the organization of ideas. Some commented on the legibility of the print, whereas others noted the convenient placement of the labels. A few appreciated the graphic visual images, while others suggested that the text helped them to explain the exhibition's concepts to their children. Some interviewees mentioned that they would have liked more information, and there were a couple of idiosyncratic responses worth noting. (See quotations below for examples of the visitors' reasoning.)

Concise, Simple Wording

> Very informative, very brief, very to the point. Not a lot of technical jargon that a lay person wouldn't be able to understand. It's just very straightforward, very enjoyable.
>
> They were clear, concise, and very understandable, didn't use big ten-dollar words.
>
> It was simple enough to understand but complex enough to see how realistic it was. That's what I liked about it.

Organization of Ideas

> The labels were pretty good, they were well written, easy to find. . . . I like the way they progressed, sort of outlining. They gave you a basic concept then build on that concept, expand on that concept. So if you just want the basic concept, you can just read the basic concept. If you're interested, you can progress further and explore more details of that.
>
> I thought the wall panels were very, very helpful. I think they give you a lot of information. I mean, you don't want to be over-saturated with information because nobody would stand there and read the full wall panel. But to have it broken down into bits and pieces, I think that's quite helpful.

Legibility

> I thought they were very good and very direct. And they took a step by step approach to explaining the exhibition. And they were also large enough to read. So, if more than one person were reading it, the visibility was good.
>
> I liked that they were on both sides, so you could have more than one or two people look at the same exhibit. The print was large enough to read from a distance. The background was bright enough so there was contrast.

Placement of Text

> I thought they were just fine. Very informative and easily read, and in the right places. . . . [That is,] easy to make eye contact, so you're not hunting for them. . . . They're closely associated with what they were talking about.
>
> They were very well done. One of the nice things I liked was that you had the same label in most of the places around the exhibits. So that no matter where you were standing, even if someone was doing the activity, you have the label there. And the other thing is the way that you had an instruction of what to do and then it told you what to look for. . . . What was a little difficult was some of the explanations being on the wall board, a little bit separated. Made it a little bit hard to figure out where you had to look.

Visual Images

Wall labels were very easy to read. I had seen lots of the pictures before. It was nice to see pictures that I think people look at. Lots of science posters and textbooks that come out have the same picture, so it's nice to see them explained.

The visual arts are very, very effective. I think they're more effective than some of the words, if you put some arrows, say, "This is what part of the visual picture looks like." It would be helpful for people to try to understand what the pictorial work shows.

Text Helps Parents Explain to Children

As a parent, I think they're very good. The way they're good for me is I'm obviously familiar with the principles being discussed. . . . Here's fourth, fifth, or sixth grade level to help explain it in. It gives me better terminology to use when I'm talking to kids.

It was very short so it sank in and you got the point. . . . Because you could then explain it to them [children] quickly while they're asking you what it is, and you can't remember!

Desire for More Information

They were understandable, very clear, succinct. I wouldn't mind if there was a little more, you know, if you could have the labels like these for people who may not be up to speed as much, and have for somebody who may be interested in a little more in-depth information, if there's some way to add that too.

I could probably have used a little bit more volume of information than was here. . . . And some discussion on how this stuff is discovered would be pretty interesting. . . . And some of the older ideas, for example, like [about] the Aurora . . . [it] says originally they thought it was a reflection of the sun and the ice particles that made it and then it explained what it actually is. . . . How these ideas come together and just educate the people that this stuff isn't handed to us on granite slabs. This is all stuff that we have to figure out incrementally over time.

Idiosyncratic Responses

Most of them were clear. It's just because we didn't get the results that we would expect, we didn't know whether it was working or whether we were being stupid.

It seemed like some of the displays were geared to a younger generation. Of course, you're in a public facility so it has to be at a lower level. What was interesting was . . . on the initial part of the display . . . two words that were used—"weird," the "perspective was weird,"—and I don't remember the other one. . . . I think of a museum as being real official and strict. . . everything would be accurate and all that, and then I saw the words that seemed to me to be geared toward the younger generation, unless they're part of

> main stream language, I don't know. . . . It just seemed unusual to be in a museum setting.

Only two interviewees indicated that they had trouble with the labels in *Electric Space*. Both referred to the inconsistency between interactive components and their accompanying instructional text. In addition, one insinuated having some difficulty with understanding the concepts on the wall panels.

> For instance, on the screen where you've got the magnet and it changes which way the ray should go. It says "Press Space Button to Start," but there's obviously no space button there. . . . And some of the instructions on how they work, they seem to talk about things that aren't there. Like there was one that says, "Look at these two scenes and compare them under different lights. Press the button to turn on the lights." But there's no button. The lights are just on. And they look the exact same. I don't know if they look differently with the lights off, and with a dishrag, I don't know what you're supposed to do with that.

What Electric Space *Does Well*

Interviewees were asked, "In your opinion, what does the *Electric Space* exhibition do well?" Half of interviewees noted that the exhibition provided informative explanations. Most of these visitors specified the exhibition topics to which they referred. For instance, some interviewees thought that principles of space were explained well or in an interesting manner (see quotations 1 and 2 below). Others noted the introduction and descriptions of *plasma* (see quotation 3). Some visitors mentioned the exhibition's presentation of the sun and solar phenomena; others referred to the discussion of magnetism. Some visitors indicated that *Electric Space* does a nice job of connecting the exhibition concepts to everyday life (see quotation 4). A few interviewees spoke of the information about forces, electricity, or auroras.

> Probably the best thing, it gives you a good feel for space. And the properties and entities in outer space. . . . It gives you a good overall conceptual idea of space. And kind of redefines it from what you might have seen from science fiction literature, movies, and books. And even what I learned back in high school, it kind of redefined that. (1)

> To capture someone to understand that there's this whole new field of knowledge. At least in my case. I didn't know anything about it. And that it's interesting and it's a fascinating process that's going on out there, you know. When you walk outside and gaze up in the night, all of a sudden you think about all this web of activity that's going on. It's not a silent, still and empty place. (2)

> [The exhibition] describes plasma and how much it affects the earth and space. Most people don't realize it. (3)

> [The exhibition] ties the idea of the way magnetism and plasma affect what's going on on the earth. [It] helps explain some of the phenomena that you'd see everyday. How a compass works, northern lights, static on the radio, and stuff. (4)

One-quarter of interviewees appreciated the hands-on components (see quotations 1 and 2). One-fifth praised the visual quality of the exhibition (see quotations 3 and 4).

> I liked all the hands-on, I think there were pretty good examples to give you an idea of things you wouldn't normally think about. (1)

> It shows them [children] by experiences, like what happened with the molecules over there, that they couldn't understand if you just tried to explain it to them. (2)

> It's very demonstrative. Let's you visually see what the material's presenting. It gives you a better grasp of what they're talking about, when you can actually see what's physically happening. (3)

> It visually, graphically demonstrated the sun's solar flares and magnetic properties, shown ones that existed and showed the different ways that they were seen, by visual and by X-rays, and to show that they existed and how the aurora was created. . . .(Can you explain what you mean by visual and what you mean by graphic?) . . . Graphical I think of as being art and visual I think of as being more like a photograph, an actual photograph plate. The sun being blocked out, the solar eclipse, whereas that one over there is a drawing, the red one. (4)

One-fifth of interviewees believed *Electric Space* is effective at interesting and educating children (see quotations 1 and 2 below). Others noted, more generally, that the exhibition teaches a "difficult concept" or provides "a lot of information" for everyone. Some interviewees specifically mentioned how the exhibition, employing a variety of interpretive strategies, effectively conveys its messages without using scientific jargon (see quotations 3 and 4).

> I would say from a child's standpoint, they're very interesting displays, like the plasma and the gasses. And, different things can be very entertaining, but also get across the message that goes along. Probably would take someone to explain it them, they could see it happen. I think they would enjoy it. (1)

> "Gives you neat things to play with," that's what my son said. . . . I would think it's a really good learning tool. It helps the little kids when they got a question, "Why does the sun do this? Why does the wind?" I mean, different stuff like that, they can look here. It may not be the *Electric Space*, but exhibits like this would help them learn a little bit about it. (2)

> I think it tries to make explaining energy in space interesting enough and to show you how it works so that you can relate to it. Not just to talk in generalities or to talk about some "sciency" terms. It shows you real practical things, what it means. So, that makes it easier to understand. (3)

> I'd say as a whole, because of the combination of large photos, simple text, . . . [for] each particular segment that they took, it conveys the message that they're trying to get across. For example, the magnetism and the plasma display, it was simple enough but it was interesting enough. It would catch your eye and you could understand what it was saying and yet it wouldn't overwhelm you. I think that the combination of photos and hands-on actually got the message across. That's what I liked about it. (4)

A few interviewees noted that the exhibition "addresses a lot of the topics on lots of different levels" and, thereby, communicates to a broad audience (see quotation 1 below). Two visitors particularly appreciated the inclusion of computers in the exhibition (see quotation 2).

> It shows us things that we don't normally see with our eyes. Forces are at work that we don't normally think about. Particularly things that are larger than our planet, you know. There's a lot of hands-on opportunity here, so I think a lot of people who learn visually or tactilely can learn, even if they don't read things. . . . This gives you an opportunity no matter what your preference. (1)

> There were computers that you could use when you first enter the exhibit. My kids and husband sat down and really enjoyed those. And I think, since we're in a computer age, maybe more exhibits of that nature might be attractive to people. (2)

Only one interviewee had difficulty naming a specific aspect of the exhibition in response to this question. When probed for what she liked about *Electric Space*, this visitor responded, "Everything. I like it a lot. I just like space."

Parts of Electric Space *that Need to Be Improved*

Interviewees were asked what parts of the exhibition need to be improved. Nearly half of visitors suggested no improvements, explaining that they thought the exhibition was fine the way it was or that they could not think of anything.

Some interviewees noted the "broken" components and, hence, the need for better maintenance of the exhibition. This was an issue particularly at VASC, because nonfunctioning components were left on the floor there, unlike at MSC.

> The one part where they had the exhibit of the aurora lights wasn't too interesting. It just showed a light down at the bottom and then it said you could hit a button to change the magnetic field, it didn't make any difference at all. [*The Terrella was not working at VASC*.]

> You need a pencil! [*for the Solar Sprinkler Spirograph*]

Some visitors, finding the layout of the exhibition confusing, requested "an easier path" (see quotation 1 below). This was a problem particularly at VASC. At MSC, on the other hand, a

few interviewees were concerned with the potential for crowding within the exhibition (see quotation 2).

> I know that there is a direction that you should go to keep learning, and that was hard to see, the way the panels were set up. There should be arrows, or have them numbered. (1)

> Probably needs to be spaced out a little bit more. It might need to be a little bit bigger. Because I noticed if there's a class in here and the other people, the single groups of people, it's hard for them to get through. You know, everybody's patient and they wait, there's a lot of different things to do if you're waiting on one or the other hands-on. . . . Like in this area, this was really crowded for a while and we didn't get to do very much with the magnets and stuff, but I mean, we can always come back later. (2)

A few interviewees thought the exhibition should have "more access to computers" or more advanced computer displays. Others wanted more exciting hands-on components or exhibits that required more involvement from visitors.

There were also numerous unique replies. For instance, one visitor wanted more in-depth information; another wanted a more precise definition of *plasma*. One visitor suggested presenting the interactives' instructions graphically rather than with text, "so you don't have to read the thing to figure out what to do." Regarding Four States of Matter, one interviewee was bothered by the fact that "you really can't feel the liquid"; another noted that the instructions and respective spheres should be correctly aligned. One visitor recommended having an explainer available in the exhibition to help visitors understand and feel comfortable with the exhibits, because "some of this stuff is kind of foreign." Another suggested having something that visitors could take home (e.g., a picture). One interviewee thought that the exhibition could use "newer exhibits"; another felt the hands-on displays should be lower for children. Lastly, one visitor noted that there was "a little bit of repetition," but continued to say, "that's good for some people here, it doesn't hurt."

Enjoyment Ratings for Electric Space

As the last interview question, visitors were asked to rate their enjoyment of the exhibition on a scale of 1 to 10, with 1 being "did not enjoy it at all" and 10 being "completely enjoyed all of it." For cases in which the interviewee named two numbers, the rating was considered to be the midpoint between the two numbers. For instance, if an interviewee responded, "I'd say an eight or nine," his rating would be counted as an 8.5. The results are listed in Table II.4. There were no differences in visitors' ratings between those from VASC and those from MSC.

Table II.4.
Interviewees' Enjoyment Ratings for *Electric Space*

Rating	%

6.0 – 6.5	12
7.0 – 7.5	20
8.0 – 8.5	43
9.0 – 9.5	14
10.0	12

The most frequent rating was 8 to 8.5, given by close to half of interviewees. Those who rated *Electric Space* an 8 to 8.5 gave a variety of reasons, both positive and negative, for their responses.

> I'd give it about an 8 1/2. . . . Because it had a combination of a good variety I think, hands-on stuff, stuff to look at and pictures on the wall that show how this stuff is encapsulated into a cosmic sphere. The 1.5 that would make it 10 is just because I didn't have enough time to play with everything.

> I'd probably give it about an eight. . . . It was hard to follow [the content] through with it being [arranged] as it was. And some of the definitions weren't real clear.

> Oh, probably an eight. . . . 'Cause I think that if I had had direction to follow it well, it would be a ten.

Interviewees who rated their enjoyment of the exhibition lower (i.e., 6 to 7.5) also gave a variety of responses. Some focused on their lack of interest in the subject matter.

> I would say either a six or a seven. I guess just 'cause it's just middle of the ground, nothing turned me off completely and nothing turned me on, it didn't excite me that much, just middle of the ground.

> I'd say probably a six. . . . I would have given it more if they [interactives] had worked a little better, I guess, the maintenance. And also if it had a little more structure to it, connecting things that they [children] can understand. It seemed to jump from one thing to another.

> About a seven and a half, eight. It's interesting to find out about magnetic fields, and everything else. It's just, it needed to be improved. Some of this stuff I just had no clue of what they were talking about.

Of interviewees who rated their enjoyment of *Electric Space* higher (i.e., 9 to 10), half provided rather vague reasoning for their ratings. Examples of the more explicit responses follow:

> Ten. [Because] it's very well organized. You can go from one to another without spending too much time. It's concise. It's quick. You can learn a lot in a short span of time. And retain it because it's visual.

I'd definitely put you up there at a nine, ten. . . . 'Cause you're showing one or two concepts . . . with a multitude of displays. You're showing it through different mediums, between the sound, the sight, the visual, and the graphics, and text. So you can absorb the information from the different mediums.

I completely enjoyed it. . . . I just think it was presented well, and as you went around step by step, you could build on what you started in the first part of the exhibit.

Probably a nine. . . . I was comfortable because it reinforced all the stuff that I already knew. And I actually learned a lot of new stuff which I actually didn't expect to learn when I came in here. Went pretty in-depth into it. Great pictures. Lots of neat stuff to see.

DISCUSSION AND RECOMMENDATIONS

DISCUSSION

As a traveling exhibition, *Electric Space* seeks to excite and educate a broad audience about the interdisciplinary concepts associated with space science. As the front-end evaluation discovered, such concepts are unfamiliar to many visitors. Employing a wide range of media, including interactive displays, text panels, brilliant visual images, and videotapes, the exhibition offers hands-on experiences to concretize abstract information.

When asked what *Electric Space* does well, half of interviewees noted that the exhibition provides informative explanations. Visitors mentioned that they learned about plasma, the sun, auroras, and magnetism. In fact, when presented with topics from the exhibition, over four-fifths of interviewees were able to talk about one or more of them. Over one-quarter of interviewees discussed magnetic fields, the states of matter, or the sun; over one-fifth spoke about plasma, radiation, or auroras.

From front-end evaluation, we know that visitors' prior knowledge of *Electric Space* concepts is not extensive. Hence, the question arises, From what components are visitors experiencing the exhibition's subject matter? The tracking data clearly indicates that visitors' usage of the exhibition focused on interacting with hands-on displays. This was especially the case for visitors accompanied by children. Among those tracked, every visitor stopped at an interactive component while in *Electric Space*. The median percentage of time spent at interactives was 85 percent, compared to 3 percent spent at text panels. In fact, 40 percent of the tracked visitors did not stop at any text panels.

It seems, therefore, that visitors are gaining their understanding of *Electric Space* concepts primarily from the interactive components. It must be noted, however, that observations are not the most effective measure for determining reading behavior, because visitors can read as they move through an exhibition without noticeably stopping. In other words, though visitors may not completely stop to read an entire wall panel, they may peruse the text as they stroll. Nonetheless, given that interviewees focused on and specifically indicated their appreciation of the hands-on activities, we can safely assume that participation with interactives forms visitors' principal experience and source of information in *Electric Space*.

One of the most successful interactive components was Four States of Matter, at which 70 percent of visitors stopped and to which several interviewees referred. Reflecting on the design of this component may identify characteristics that helped to make it successful with visitors. To begin, Four States of Matter drew visitors in with relatively familiar concepts (i.e., solid, liquid, and gas) and from this basic level, they were smoothly led to the unfamiliar (i.e., plasma). Each state was demonstrated very concretely, and the similarity between the spheres of matter made comparison apparent. All of these features (i.e., starting from a familiar base, concreteness, and comparisons) have been shown to be effective means of conveying new information (Ziebarth, et.al., 1992; Korn, 1993; Serrell, 1996).

In contrast, the Plasmaspheres, when presented alone, though very high in attracting power, may not have been as successful at conveying meaning to visitors. The sight of plasma was unfamiliar, and its behavior was not intuitive. Visitors were uncertain of what to expect, creating their own comparisons by relying on past experiences in which touching a sphere made their hair stand on end.

Because visits in *Electric Space* revolved around hands-on displays, we can assume that a large portion of visitors' understanding of the exhibition resulted from the interactive components and their associated explanations. In fact, when asked about the exhibition's labels, most interviewees spontaneously referred to the text on the interactives rather than to the wall panels. Interviewees went so far as to suggest "graphical" instructions for the interactives rather than text, as further indication that they are more interested in "doing" than in "reading." These findings highlight the importance of developing instructional text for interactives that is highly integrated with the exhibition's conceptual messages.

Two primary concerns emerge from the apparent usage patterns in *Electric Space*:
1. How to utilize the interactive components most efficiently, so that they will convey to visitors the primary exhibition themes?
2. How to make the textual, or conceptual, information more attractive, so that more visitors will attend to it?

RECOMMENDATIONS

Interactive Components

In using the interactives, four-fifths of visitors had no difficulties. Nonetheless, due to the primary role played by the interactives, the exhibition, as a whole, would be well served by ironing out as many of the shortcomings as possible and further enhancing the activities where appropriate. The following suggestions are offered in that vein:

- Because the visitor experience in *Electric Space* revolves around the interactives—sometimes to the exclusion of text panels, in the explanatory labels for the interactives include any definitions of terminology or background themes that would provide context for the displays and amplify their intended meaning.

- Similarly, though visitors were able to operate any given interactive, they were not always aware of what the component was demonstrating or why it was behaving as it was. So that visitors are not left to guess or to reinforce incorrect notions, include on the interactives a text label that aids visitors in understanding the scientific principle on display.

- Because visitors indicated an uncertainty about the functioning of some interactives, specifically state on each display what visitors should expect to see or hear and how long the response should take.

- A couple of visitors referred to an inconsistency between what they read on an interactive's label and what they could find on the display itself (e.g., missing buttons). Ensure that within the text for each interactive display there is no reference made to nonexistent component parts.

- A chronic problem referred to at both installation sites was the lack of necessary supplies for the Solar Sprinkler Spirograph. To use this interactive properly, visitors must be provided with a writing implement and paper (preferably paper with a star stamped in the center). Attempt to attach a holder for a writing implement permanently to the display table to eliminate visitors' frustration.

- Ensure that the interactive component can be used successfully by children as well as adults. Children, of course, should not have to be lifted; adults should not have to kneel. Stools of various heights may be in order, so that components, such as the Emission Spectra from Stars, can be used comfortably by all.

- Review all of the visitors' own suggestions for improving the interactive components, located in Appendix D.

Textual/Conceptual Messages

Practically all of the interviewees commended the exhibition's text, noting such characteristics as its clarity, conciseness, organization, legibility, and placement. At issue is not how to improve the text panels per se, but rather how to make textual (or conceptual) messages more attractive to visitors as they compete against the typically more inviting hands-on displays. This is an age-old dilemma. In *Electric Space*, the clarity and brevity of the text panels as well as the way in which they are incorporated with the interactives, appears to be relatively successful, considering that when visitors leave the exhibition they are able to speak about some of the relevant concepts. Nonetheless, the following suggestions may promote greater comprehension of the exhibition's conceptual content.

- Wherever appropriate, reiterate the central themes and repeat any significant definitions (e.g., that of plasma). Given that visitors, as a whole, stop at so few wall panels, each panel must convey its own message without relying on any background material presented on a different panel.

- The layout of the exhibition should optimize the flow of information as well as the audience traffic flow. The exhibition modules (e.g., The Plasma State of Matter, Our Dynamic Sun, etc.) should be configured in such a way that one concept leads naturally into the next. Otherwise, visitors are left with disjointed ideas (e.g., magnetism, plasma) between which they may perceive no connection.

- Studies have shown that text associated with objects has a greater attracting power than does stand-alone text (Munley, 1982; Korn and Ades, 1995). Wherever possible, integrating

objects with the text may be effective at encouraging more attention to textual messages. However, due to the abstract nature of the subject matter in *Electric Space*, actual objects are not always appropriate to the concepts. When addressing abstract ideas, media other than text may be in order. For instance, a semi-enclosed narrated video presentation with seating may be a more efficacious mode of communicating abstract exhibition themes.

Responsibilities of the Host Site

Though simple and obvious, the responsibilities of the host site must be noted, as they determine the ultimate success or failure of a traveling exhibition.

- Provide a guide pamphlet that instructs hosts on the optimal layout of the exhibition and the importance of attempting to comply with the suggested configuration.

- Emphasize to host sites that the Solar Sprinkler Spirograph must be supplied daily with paper in order for visitors to use it properly.

- Note in the guidance materials that the effects of the plasmaspheres are most apparent under low light levels, so they should not be positioned in areas of sunlight.

- Request that hosts regularly monitor the components to assure that each is functioning properly. Suggest that they promptly repair nonfunctioning components or remove them from the installation. Such a practice will alleviate the confusion, frustration, and dissatisfaction encountered by visitors as they futilely attempt to work a broken component, as well as spare the display from further damage.

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APPENDICES

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