Invisible Forces Exhibition: Using Evaluation to Improve an Exhibition

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Abstract

The California Museum of Science and Industry's *Invisible Forces* exhibition was designed to convey specific concepts related to electricity and magnetism, capture visitor interest for durations of 15 minutes or more of continuous use, be self-contained and comprehensible without reference to other exhibits or extensive text, and appeal to a broad range of ages and backgrounds. The task for this project was: (1) to determine how well the *Invisible Forces* exhibition on electricity and magnetism was succeeding as currently configured; (2) given the feeling by staff that it was not completely succeeding, to use remedial evaluation results to propose how best to rectify deficiencies simply and inexpensively; (3) to facilitate changes in the exhibition; and (4) to re-evaluate to determine how well the exhibition was succeeding as modified. Evaluators attempted to understand the exhibition as a whole. However, most of their attention was focused on a subset of six exhibit elements.

Based upon the results of the preliminary assessment of the *Invisible Forces* exhibition, it was determined that the strengths of the exhibition were the physical characteristics of the exhibit elements—the devices seemed to be intrinsically compelling and attractive to visitors. The major liabilities were that, by and large, both the function and conceptual underpinning of the exhibit elements were unclear to the large majority of visitors. Consequently, the major change decided upon was a manipulation of the text and graphics of the exhibit elements. Each element was provided with a short question which focused visitor attention on the major conceptual message, and, if warranted, ancillary directions and graphics to facilitate proper mechanical utilization of the exhibit. Text was written in both English and Spanish.

These modest changes resulted in dramatic improvement in visitor behavior and comprehension. Among them were a 50% increase in the amount of time visitors spent using the exhibition, a doubling in the correct usage of exhibit elements and a 136% increase in conceptual understanding of the exhibition as a whole (the greatest gains were by Hispanic visitors). The use of labels containing short questions in English and Spanish effectively enhanced both exhibit use and comprehension.

Introduction

The California Museum of Science and Industry's *Invisible Forces* exhibition was designed to actively engage the public in the investigation of basic phenomena and applications of electricity and magnetism. Collectively, the exhibition was intended to convey specific concepts related to electricity and magnetism and to capture visitor interest for durations of 15 minutes or more of continuous use. Additional goals for the exhibition were that it should be self-contained and comprehensible without reference to other exhibits or extensive text, and that the exhibition should appeal to a broad range of ages and backgrounds.

The study reported here was designed: (1) to determine how well the *Invisible Forces* exhibition on electricity and magnetism was succeeding as currently configured; (2) given the feeling by staff that it was not completely succeeding, to use remedial evaluation results to propose how best to simply and inexpensively rectify deficiencies; (3) to facilitate changes in the exhibition; and (4) to re-evaluate to determine how well the exhibition was succeeding as modified. The project was begun on September 23, 1991. Although an understanding of the exhibition as a whole was important, attention was focused on a subset of exhibit elements. Six of the twenty exhibit elements, *Simple Circuits, Power the Electromagnet, Electromagnet, Find the Electromagnet, Measuring Current* and *Every Kilowatt Counts*, were targeted for improvement.

Approach

In the first phase of the project, the evaluator spent time both observing and measuring visitor responses to the exhibition and engaging museum staff in interaction and discussion about the exhibition. The second phase focused on making changes to exhibition elements and evaluating their effectiveness. All changes to exhibit elements represented a team effort between CMSI staff and the project evaluator.

Changes to the *Invisible Forces* Exhibition:

Based upon the results of the preliminary assessment of the *Invisible Forces* exhibition, it was determined that the strengths of the exhibition were the physical characteristics of the exhibit elements—the devices seemed

to be intrinsically compelling and attractive to visitors. The major liabilities were that, by and large, both the function and conceptual underpinning of the exhibit elements were unclear to the large majority of visitors. Consequently, the major change decided upon was a manipulation of the text and graphics of the exhibit elements.

For each element one large type label was created; each one comprised of a short question which focused visitor attention on the major conceptual message, and if warranted, ancillary directions and graphics to facilitate proper mechanical utilization of the exhibit. Changes were made to 19 out of 20 exhibit elements. Only the *Jacob's Ladder* was excluded since it was deemed to be more of an attention-attracting display than an interactive teaching exhibit.

All changes were composed and produced on a MacIntosh Computer, in-house. One label was commercially enlarged, several were enlarged in-house on a photocopy machine, and one banner was run off, also in-house. Other than staff and consultant time, out-of-pocket costs for this effort were negligible. Changes were viewed as temporary and experimental. Versions were developed, put on the floor, and in several cases modified and replaced. This process took about two weeks of concentrated effort. A sample label is shown below.

Sample Label from *Invisible Forces*

Magnetic Gears

Turn a magnet *very slowly*

Why do other magnets turn?

Engranejes Magneticos

Gire un magneto *lentamente*.

¿Por que los otros magnetos se mueven?

Procedures And Results

Demographic Data

A stratified sample of visitor utilization of the museum was conducted. Data were collected on weekdays and weekends, mornings and afternoons, to

determine the overall age, sex and racial makeup of the museum's population. The sample was biased towards weekend days since these were generally acknowledged as the busiest times. A total of nine samples were taken, 5 on a Saturday, 2 on a Sunday (Raider's home football game day) and 2 on weekdays. Each sample period consisted of sitting at the main entrance to the Technology Hall for 30 consecutive minutes and recording by age, sex and race every visitor that entered the museum during that time.

During the four and a half hours of investigation, a total of 1,263 visitors were observed (Table 1). Roughly half of all visitors were white, 10% were black, and close to 40% were Hispanic. Less than 5% of CMSI's visitors appeared to be of Asian origin. More than half of all visitors were male, mostly young. The visiting population was evenly divided between individuals below the age of twenty and those over the age of twenty years. Based upon this sample, it appears that CMSI attracts very few older visitors—only 6% of visitors are over the age of 50 years. CMSI currently attracts more males than females.

In addition to this general information, more in-depth background data were collected from a sample of 102 visitors—50 white and 52 black (Falk, 1992). These subjects were all adult members of family groups. The survey indicated that this population was predominantly middle class—economically, occupationally and educationally. There were a significant number of blue collar and white collar clerical visitors represented in the sample.

Nearly 80% of the visitors surveyed indicated having a high or very high interest in science. Worthy of note is that all individuals indicating a very low interest in science stated that they came to the museum because someone with a high interest had brought them. Nearly half of the visitors were first time visitors to CMSI, though nearly a third were regular visitors. Nearly all indicated that they had been to one or more museums, zoos, aquaria or nature centers within the last year. The majority were taken to museums by their parents when they were children.

These visitors gave a variety of reasons for visiting, but word-of-mouth (from relatives, friends and children) accounted for the largest percentage of reasons given, followed by prior visits. Less than 10% indicated that some kind of media promotion influenced their decision to visit. As a group, these visitors appear to be active participants in both religious and sporting activities. Six survey questions were intended to provide a psychographic profile (cf. Hood, 1985) of those who participated. This profile indicated that respondents were highly concerned about the social nature of the museum experience and felt a strong need to feel welcomed and comfortable in the setting.

Invisible Forces Data

The major focus of research was on visitor behavior within, and understanding of, the *Invisible Forces* exhibition.

Time

A total of 203 visitors was observed and timed from the moment they entered the *Invisible Forces* exhibition to the moment they exited. One hundred and one visitors were tracked prior to changes in the exhibition and 102 were tracked subsequent to changes in the exhibition. These visitors were selected at random and were generally representative of the CMSI museum population and included children and adults, whites, blacks and Hispanics.

From Table 2 it is clear that all exhibits were attended to by some visitors, both before and after changes. Only *Electric Charge* (1), *Power the Electromagnet* (14), and *Jacob's Ladder* (20) were viewed by more than half the visitors prior to changes in label copy. Subsequent to changes, *Magnetic Gears* (3), *Magnetic Forces* (4), and *Simple Circuit* (6) can be added to this list. In addition, *Magnetic Patterns* (5) and *Conductor or Insulator* (12) approach the 50% mark. Both before and after changes, no exhibit was viewed by all visitors, though some visitors viewed all exhibits. With one exception (*Measuring Resistance* [7]), all exhibit elements were viewed more often after the changes (a 22% increase). Nearly 3 out of 4 visitors stopped at the *Power the Electromagnet* exhibit *(14)* after changes were made. The three exhibit elements located on the back of the *Simple Circuit* Exhibit, *Measuring Resistance* (7), *Measuring Current* (8) and *Measuring Volts/Amps* (9) remained under-utilized; as did *AC and DC* (13). *Motor or Generator* (17) nearly doubled in use after changes were made.

Table 3 highlights the exhibit element to which visitors were first attracted. Overall, the patterns of first attraction remained relatively constant. Several elements show increases in first attractiveness after changes. They are: *Power the Electromagnet* (14), *Electric Fields* (2), *Measuring Current* (8), *Measuring Volts/Amps* (9), and *Every Kilowatt Counts* (19). No significant decreases occurred. *Jacob's Ladder* at the front of the exhibition area was the most highly attractive exhibit both pre- and post-changes.

Figure 1 summarizes the distribution of total time visitors spent in the *Invisible Forces* hall. Both before and after distributions were basically bimodal—either visitors spent relatively little time or they spent considerable time. The differences before and after changes were enormous, with a significant increase of visitor time spent in the exhibition. Whereas prior to the addition of extra label copy over a third of visitors were spending less than two minutes in the exhibit, after changes less than five percent were spending this little time. The median of the short-timer's stay had shifted from 31 seconds to one minute, to four minutes-thirty-one seconds to five minutes—nearly a five-fold increase. The number of visitors spending longer times also increased. Initially, 14% of visitors spent 10 or more minutes in the exhibition. Subsequent to the addition of improved labels, 22% of visitors were spending more than ten minutes in the

exhibit—nearly double. Overall, the median time visitors remained within the exhibition increased by 50%, from four minutes to six minutes (see Table 4).

Tables 5-7 document the shifts in visiting time at the *Invisible Forces* exhibition as a function of age. Positive changes occur for all three age groups (children, teens and adults). Children and teens evidenced the greatest positive shift. Table 8 shows male time in the exhibition indicating that subsequent to changes, males spent longer in the exhibition. Female time in the exhibition did not change significantly.

Prior to the changes, less than 3% of visitors spent more than 13 minutes in the exhibition, while only one visitor spent over 17 minutes. After changes, over 10% of the sample spent more than 13 minutes in the exhibition, and four visitors stayed for over 17 minutes.

Behavior

Data were collected based on focused observations of visitor utilization of five of the six target exhibit elements (Table 8). For each element, specific non-verbal behaviors were identified that were indicative of "appropriate" usage—behaviors that demonstrated successful manipulation of the exhibit element. For example, in the exhibit *Power the Electromagnet,* visitors who successfully managed to power the electromagnet so that it attracted and lifted the steel balls were deemed to have exhibited "appropriate" behavior. In *Find the Electromagnet* it was observed during preliminary observation that not a single visitor pointed to parts of the exhibit, even though pointing was one of the behaviors which suggested that a visitor was actually attempting to find the electromagnets in the exhibit. A complete list of behaviors utilized for each exhibit can be found in Falk's report (1992). *Simple Circuits* was not observed since baseline data suggested most visitors already exhibited "appropriate" usage of this element.

Table 9 shows that after changes to the exhibition, a majority of visitors were able to manipulate the exhibits in an appropriate manner, most notably at *Power the Electromagnet.*

Understanding of Exhibits

A total of 308 visitors were interviewed about their perception of what the six target exhibit elements were communicating—156 prior to changes and 152 after the changes were installed (cf. sample protocol, Falk, 1992). The sample included roughly equal numbers of children and adults, 59% males and 41% females, 41% whites, 15% blacks and 44% Hispanics. Data were collected in both English and Spanish.

Tables 10 and 11 summarize the significant changes in understanding that changes in words and graphics produced. The data revealed marked improvements in understanding for all target elements. Only the *Electromagnet* exhibit showed moderate as opposed to large gains.

Table 12 shows that both sexes showed gains in understanding as a function of changes in label copy. Tables 13 and 14 show comparable improvement as a function of age and race. The greatest changes appear to be among the teen cohort with nearly a five-fold increase in comprehension.

Due to relatively modest gains of the *Electromagnet* and *Find the Electromagnet* exhibits, Tables 15 and 16 are provided to show how age influenced understanding of these exhibits. For the *Find the Electromagnet* exhibit element, most of the success appears to be among older visitors—those above the age of 13. This does not seem to be the pattern for the *Electromagnet* exhibit.

Figure 2 graphically shows the significant change in comprehension that the intervention created. Correct responses rose from 28% prior to changes to better than 66% after changes.

Discussion

Demographics

Overall, CMSI, like most science and technology museums, is heavily utilized by family groups (ASTC, 1976). The CMSI visitor population, perhaps in large part because of its free admission policies, is more racially diverse than most other comparable museums (ASTC-AAAS, 1987). Based upon a *USA Today* article on racial diversity ("Most diverse," 1991), CMSI's visitor profile is roughly representative of the greater Los Angeles area. The only racial/ethnic population under-represented at the museum is visitors of Asian origin. For them, the museum is attracting approximately half the expected percentage.

The more detailed demographic profiles reveal a visitor population that is at once middle class and generally science oriented—neither of which is surprising. Although the museum's visitors are racially representative of the greater L.A. area, they are not financially and educationally representative. CMSI's population, like that of most museums, is a decided cut above the norm (cf. Falk & Dierking, 1992). The museum's visitor population is roughly evenly split between regular or repeat visitors and first time visitors. Almost all, though, are museum-oriented, visiting some museum at least once a year. This is a population that values science museums and, by and large, has done so since childhood. The psychographic data reinforce these conclusions and further suggest a visitor population that is highly concerned about the social nature of the museum experience and feels a strong need to feel welcomed and comfortable in the setting.

There does not appear to be any typical visitor flow pattern at CMSI. Even within the *Hall of Technology*, the multiple entrances and exits make generalizations difficult. Overall, though, it could be said that visitors to the *Technology Hall* were highly likely to visit the *Invisible Forces* exhibit, even if only briefly. What percentage of the total museum visitors enters

the *Technology Hall*, we can not estimate. As is true of most exhibitions, visitors to *Invisible Forces* could be said to fall into one of two populations—those who spend only a cursory amount of time engaged, and those who spend a considerable amount of time (cf. Falk, 1982). Museum fatigue did not appear to be a major factor in affecting these distributions, nor did concerns about seeing/doing the museum (cf. Falk, 1991).

Invisible Forces

The modifications which were introduced resulted in profound changes in the overall usage of the *Invisible Forces* exhibition, in the ability of visitors to successfully manipulate the exhibit elements, and in the comprehension levels of visitors. Since the changes made in the exhibition were primarily at the "micro-level"—specifically in the form of label copy and graphics, rather than macro-level manipulations of exhibit appearance, it is not surprising that there was relatively little change in exhibit attracting power (Table 3). Although there were some minor fluctuations, the basic overall pattern of attraction remained constant.

The overall increase in percentage of exhibits viewed is attributed to longer visitation time within the exhibition (Figure 1). Improvement in visitor perception of success led to increased time in the exhibition, which in turn resulted in visitors spending more time at more exhibits. Although visitor time in the exhibition increased more than 50%, the number of exhibits visited did not change proportionately. Based upon observations, most of the extra time visitors spent in the exhibition was allocated for increased time at each exhibit element rather than for visiting more elements.

The fact that visitors spent more time in the *Electricity and Magnetism* exhibition after refinements and changes were made to words and graphics at each exhibit element is indisputable. The median time shifted from four minutes to six minutes, while the number spending moderate amounts of time (greater than four minutes) increased from 45% to 83% and the number spending significant amounts of time (defined as greater than eight minutes) increased from 24% to 37%. The number of visitors spending less than two minutes decreased from 38% to 5%. Time on task, a measure of visitor satisfaction, increased several fold pre- to post- changes in this exhibition.

There is no evidence that gender was a major factor in determining use of the exhibition. Despite most of the changes being label oriented, children under 15 years (the least likely group to read) evidenced the greatest gains in staying time. Perhaps social factors such as parental explanation played a major role.

Not only did visitors spend more time in the exhibition, as Table 9 demonstrates, visitors increased their competency at utilizing the exhibition in the intended manner. The vast majority of visitors, with the aid of one or two simple instructions, were now capable of appropriately engaging the exhibit elements.

Perhaps most dramatic was the major increase in comprehension resulting from the changes which were implemented. Prior to intervention, only about one in four visitors to the *Invisible Forces* exhibition could describe the general purpose or intent of the exhibits contained within it. After the addition of short questions, statements, and improved graphics, two out of three visitors could comprehend the basic message of the exhibition—a 136% increase. Further refinements should yield additional increases.

The results in Table 14 show that these gains were not uniform across races. All races showed improvement in comprehension after changes were made, but the improvements of Hispanic visitors are particularly notable. This population of visitors began at the lowest level of comprehension and ended with the highest level. This improvement is almost certainly a direct consequence of writing label copy in both English and Spanish. Some have questioned the overall literacy level of Hispanic visitors. Although some members of this population may in fact be illiterate, either the vast majority are not or their social network is more than compensating for the deficiencies of a few.

Six exhibit elements were targeted for focused investigation. Prior to intervention, none of the six were understandable to even a simple majority of visitors (Table 10). After changes, all but one—*Find the Electromagnet*—were understandable to a majority of visitors (Table 10). Three elements, *Power the Electromagnet, Current and Every Kilowatt Counts* were understandable to large majorities of the public. Why did the remaining three exhibit elements not achieve this measure of success?

In the case of *Simple Circuit*, despite achieving only modest comprehension at this stage (57%), significant improvement has clearly been made—only 7% of visitors could even remotely describe the intent of this exhibit element prior to intervention. With continued refinements in presentation (not all of the agreed-upon modifications to the exhibit were able to be implemented during this initial observation period), visitor comprehension levels are likely to exceed 70%.

The poor showing of *Electromagnet* and *Find the Electromagnet* suggests one of three possible explanations, or a combination of the three: (1) the changes in label copy were not sufficiently clear or comprehensible; (2) the placement of the new material was poor and as a result visitors did not see or read the new material; or (3) concepts or information these elements were trying to convey was conceptually too difficult for many visitors. It is likely that different combinations of these three problems are at work with the two electromagnet exhibit elements.

Although the possibility cannot be ruled out that label copy for these two elements was at least partly at fault, this does not seem to be the most likely explanation. The same individuals prepared copy for all 19 labels. There is no reason to believe that these two were worse than any of the other 17 prepared, particularly than the other four included in this analysis.

A problem with both exhibits was the placement of written information. One factor that distinguishes both the *Find the Electromagnet* and *Electromagnet* elements from other exhibit elements is that major parts of the copy and graphics were set horizontally, approximately 40 inches off the ground. Many young visitors may not have been able to read the words put there, even if they were so inclined. Tables 15 and 16 compare comprehension success at these exhibits as a function of age and race. Table 15 tends to support the contention that those visitors most likely to have height-related reading problems at *Find the Electromagnet*—visitors under the age of 12 years showed the least improvement despite showing large gains overall. If visitors of this age did not/could not read the new labels, then they were unlikely to derive much benefit from any changes to the exhibits. The data from Table 16 for the *Electromagnet* exhibit element do not, however, support this hypothesis. It should be noted though, that age in Table 16 is represented by only six subjects. This is an issue that would lend itself to further testing.

Alternatively, the issue may not be reading but just the ability to comprehend complex physical principles. Much of what was being presented at these two exhibits may have been conceptually over the heads of many young children, as well as adults. Reading was likely more of a factor than comprehension at the *Find the Electromagnet*, and comprehension was a major factor with the *Electromagnet* exhibit. Certainly some combination of the two could have been at work at both. This too would lend itself to further testing.

Conclusions

The *Invisible Forces* exhibition, as currently configured, does succeed at engaging the public in investigating basic phenomena and applications of electricity and magnetism. Observations suggest that the vast majority of visitors find the exhibition to be fun and engaging. Visitors derive considerable enjoyment from the exhibition when they feel they are using it successfully – which for the most part they now do. Most visitors find the machines kinesthetically enjoyable and highly attractive. The fact that very nearly all visitors (95 out of 100) now feel compelled to spend more than a couple of minutes in the exhibition area is testimony to this appeal. The exhibition's goal of creating an environment where the majority of visitors will continuously remain for 15 minutes and upward is still not being met nor does it appear to be a realistic goal. Although some visitors become tremendously involved with the exhibition, a utilization time of 8 to 10 minutes is probably a more realistic optimum time target.

The goal of appealing to a wide range of ages and backgrounds does appear to be achieved. CMSI attracts a highly diverse audience, both racially and in terms of age. The *Invisible Forces* exhibition appears to be attractive to all sectors of the museum's population.

Although the exhibition is in places intellectually challenging, it appears that it is possible to successfully communicate the conceptual basics of electricity and magnetism to the public. There is evidence to indicate that most visitors enter the exhibition with only a minimal understanding of the subject. Therefore, as is currently the case, the exhibition needs to provide very basic information and reinforce what general understanding the public already possesses. The data from this study should be evidence that this is possible. This study also supports the contention that with a minimum of words it is possible to design an exhibit that communicates important physical principles to an intelligent but naive public.

Graphic elements are extremely important parts of the success of the exhibit, but most require some text as well. The combination of quality graphics and limited text appears to be an excellent mechanism for conveying information to the public. This study reinforces the contention that visitors *will* read if they are interested in the topic/exhibit and if the text is limited and legible. As evidenced by this study, writing labels in the form of short questions can be an effective strategy for both communicating information and for inviting cognitive interaction. For a museum such as CMSI with a large Hispanic population, questions should be written in both English and Spanish.

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Race	Males			Females			
	<20	20-50	50>	<20	20-50	50>	TOTAL%
White	168	178	25	97	132	21	49.2
Black	41	21	3	20	29	2	9.2
Hispanic	157	100	4	121	76	11	37.1
Asian	16	10	3	9	10	7	4.4
TOTAL%	30.2	24.5	2.8	19.6	19.6	3.2	
		57.5			42.5		

Table 1. Visitor profile by age, sex, and race.

Exhibits Attracted To	type pre	post	Overall
1	56.0	60.4	57.9
2	37.0	44.6	40.6
3	41.0	53.5	47.0
4	38.0	51.5	43.1
5	41.0	47.5	44.1
6	47.0	59.4	53.0
7	21.0	14.9	17.8
8	19.0	20.8	19.8
9	20.0	22.8	21.3
10	21.0	31.7	26.2
11	26.0	28.7	27.2
12	40.0	48.5	44.1
13	14.0	18.8	16.3
14	53.0	70.3	61.4
15	30.0	41.6	35.6
16	23.0	28.7	25.7
17	17.0	31.7	24.3
18	27.0	39.6	33.2
19	32.0	30.7	31.2
20	54.0	53.5	53.8
Total	*	*	*
Number of Replies	100	101	202

Note: * Multiple answers allowed.

Table 2. The exhibit elements visitors attended to prior to and after changes.

1st Exhibit To View	type pre	post	Overall
1	17.0	8.9	12.9
2	9.0	15.8	12.4
3	2.0	4.0	3.0
4	4.0	6.9	5.4
5	8.0	5.0	6.4
6	9.0	11.9	10.4
7	2.0	1.0	1.5
8	2.0	5.9	4.0
9	1.0	5.0	3.0
10	1.0	1.0	1.0
11	1.0	0.0	0.5
12	1.0	0.0	0.5
13	0.0	0.0	0.0
14	1.0	5.0	3.0
15	1.0	1.0	1.0
16	0.0	0.0	0.0
17	0.0	0.0	0.0
18	1.0	0.0	0.5
19	0.0	2.0	1.0
20	40.0	26.7	33.2
Total	*	*	*
Number of Replies	100	101	202

Note: * Multiple answers allowed.

Table 3. The exhibit element that visitors are first attracted to.

Time in Hall	type pre	post	Overall
:00 - 2:00	37.6	5.0	19.8
2:01 - 4:00	17.2	11.9	13.9
4:01 - 8:00	21.5	47.5	33.7
8:01 or longer	23.7	35.6	28.7
Total	100.0	100.0	100.0
Number of Replies	93	101	202

Table 4. Comparison of visitors' time in hall as function of pre- to post-changes.

Time in Hall	type pre	post	Overall
:00 - 2:00	26.3	0.0	14.7
2:01 - 4:00	26.3	6.7	17.6
4:01 - 8:00	10.5	26.7	17.6
8:01 or longer	36.8	66.7	50.0
Total	100.0	100.0	100.0
Number of Replies	19	15	34

Table 5. Visitors under fifteen years' time in hall pre and post changes.

Time in Hall	type pre	post	Overall
:00 - 2:00	38.9	0.0	17.9
2:01 - 4:00	5.6	10.5	7.7
4:01 - 8:00	16.7	57.9	35.9
8:01 or longer	38.9	31.6	33.3
Total	100.0	100.0	100.0
Number of Replies	18	19	39

Table 6. Teenaged visitors' time in hall as function of changes.

Time in Hall	type pre	post	Overall
:00 - 2:00	41.1	7.5	21.7
2:01 - 4:00	17.9	13.4	14.7
4:01 - 8:00	26.8	49.3	37.2
8:01 or longer	14.3	29.9	21.7
Total	100.0	100.0	100.0
Number of Replies	56	67	129

Table 7. Adult visitors' time in hall as function of changes.

Time in Hall	type pre	post	Overall
:00 - 2:00	46.2	4.8	23.1
2:01 - 4:00	19.2	9.7	13.7
4:01 - 8:00	19.2	50.0	35.0
8:01 or longer	15.4	35.5	25.6
Total	100.0	100.0	100.0
Number of Replies	52	62	117

Table 8. Male time in exhibtion before and after changes.

	Exhibit Elements Observed				
	Power an Electromag.	Electromag.	Find the Electromag.	Current	Every Kilowatt Counts
Appropriate Behavior	86%	55%	70%	62%	67%
Inappropriate Behavior	14%	45%	30%	38%	33%
N	144	51	52	50	55

Table 9. Percent of visitors behaving in a manner that results in successful operation of exhibit elements.

Exhibit element questions	correct	correct or incorrect incorrect	Total	Number of Replies
Simple Circuits (ball tra	7.1	92.9	100.0	28
Power an Electromagnet (t	30.6	69.4	100.0	49
Electromagnet	40.9	59.1	100.0	22
Find the Electromagnet	17.6	82.4	100.0	17
Current	28.6	71.4	100.0	21
Every Kilowatt Counts	45.0	55.0	100.0	20
Overall	28.0	72.0	100.0	157

Table 10. Visitor understanding of six target exhibit elements prior to changes.

Exhibit element questions	correct or incorrect: correct	incorrect	Total	Number of Replies
Simple Circuits (ball tra	56.5	43.5	100.0	23
Power an Electromagnet (t	79.2	20.8	100.0	24
Electromagnet	56.5	43.5	100.0	23
Find the Electromagnet	44.0	56.0	100.0	25
Current	70.6	29.4	100.0	17
Every Kilowatt Counts	84.2	15.8	100.0	38
Overall	66.2	33.1	100.0	151

Table 11. Understanding of the six target exhibit elements after changes.

Type of interview:	Sex: male	female	Overall
pre-test	28.6	34.6	30.8
post-test	71.4	65.4	69.2
Total	100.0	100.0	100.0
Number of Replies	91	52	143

Table 12. Correct understanding of exhibit elements as a function of gender.

Type of interview:	Age: 8 - 12 years	13 - 19 years	20 - older	Overall
pre-test	24.1	16.7	36.7	30.8
post-test	75.9	83.3	63.3	69.2
Total	100.0	100.0	100.0	100.0
Number of Replies	29	24	90	143

Table 13. Correct understanding of exhibit elements as a function of age.

Type of interview:	Race: white	black	Hispanic	Overall
pre-test	33.8	40.9	22.0	30.8
post-test	66.2	59.1	78.0	69.2
Total	100.0	100.0	100.0	100.0
Number of Replies	71	22	50	143

Table 14. Correct understanding of exhibit elements as a function of race.

correct or incorrect	Age: 8 - 12 years	13 - 19 years	20 - older	Overall
correct	25.0	100.0	50.0	42.3
incorrect	75.0	0.0	50.0	53.8
Total	100.0	100.0	100.0	100.0
Number of Replies	12	3	10	26

Table 15. Understanding of the Find the Electromagnet exhibit element as a function of age.

correct or incorrect	Age: 8 - 12 years	13 - 19 years	20 - older	Overall
correct	50.0	-	58.8	56.5
incorrect	50.0	-	41.2	43.5
Total	100.0	100.0	100.0	100.0
Number of Replies	6	0	17	23

Table 16. Understanding of the Electromagnets exhibit as a function of age.

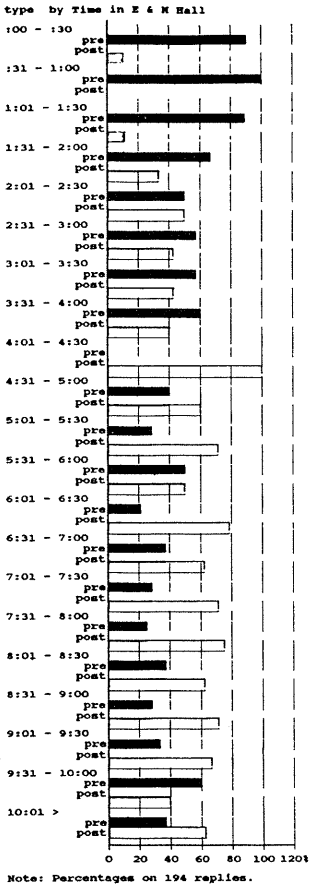

Figure 1. Time visitors spend in the Electricity & Magnetism exhibition before and after changes to the exhibit elements.

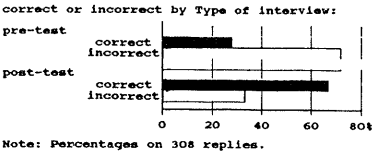

Figure 2. Overall understanding of Electricity and Magnetism exhibit elements before and after changes to exhibition.