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ABSTRACT

A series of studies of explanatory label reading and comprehension by visitors of various age groups was conducted at The Franklin Institute Science Museum in Philadelphia. A single large, complex exhibit (the Gravity Tower) was selected for case study. Adult visitors were found to read an average of only 18 percent of the labels in the exhibit halls they entered. However, they did read 68 percent of the printed material on the exhibits at which they chose to spend a longer amount of time. Children below the age of 19 did not do any significant label-reading, despite a variety of attention-getting treatments used. However, labels were significant in assisting parents in explaining exhibits to children. In the absence of printed labels, parents invented erroneous explanations. Visitors preferred labels which conveyed scientific as opposed to historical information. Finally, visitors read an average of 200 words per label, when they selected an exhibit for study. Furthermore, they felt it was important to have this printed material available so that they could elect to learn more about the particular exhibits which were of interest to them. (Appendices include guidelines for the effectiveness of printed text, formulas for testing reading level, and the study questionnaire). (Author/JN)

• GRAVITY • VELOCITY • INERTIA • FRICTION •

ACCELERATION • HEAT • PRESSURE

RESISTANCE • MASS • MECHANICAL

• ENERGY • POTENTIAL • KINETIC • ENTROPY •

What's In A Name?

A Study of The Effectiveness of Explanatory Labels In A Science Museum

BY

MINDA BORUN AND MARYANNE MILLER

THE FRANKLIN INSTITUTE SCIENCE MUSEUM & PLANETARIUM

.T'S IN A NAME?

A STUDY OF THE EFFECTIVENESS OF EXPLANATORY LABELS IN A SCIENCE MUSEUM

by

Minda Borun and Maryanne Miller

The Franklin Institute Science Museum and Planetarium

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FOREWORD

In our society, formal education is the generally accepted way to learn a skill or become a scholar or scientist. Although such school-based education is important, it constitutes only one learning mechanism. Informal learning -- the somewhat random web of experiences, facts, lessons, impressions, and accumulated knowledge that we continually draw upon -- is at least equally important. Throughout our lives, we build this matrix in a casual, self-structured and self-directed manner from conversations, books, films, broadcasts, newspapers, museum visits and a wide variety of other information sources. This informal learning may well be the primary way most people gain information about and understanding of objects and events throughout their lives. It is the means by which citizens gain information they use to make consumer decisions in their daily lives; to take positions on community issues, such as nuclear power; and to choose candidates for local, state, and federal offices.

Museums constitute a major source of informal education. They provide general support for cultural and intellectual literacy by seeking to demystify the world with exhibits and programs available to all. They are resource centers for learning about new or specialized subjects. Today, museum exhibits are making powerful and important statements about the role of creativity; the power of thought; the interdependence of science, technology, the arts and humanities; the significance of the entrepreneur and of the innovator.

Museums and other informal educational media supplement school learning by providing unique resources not available through schools. Museums are vast resources of objects, experiences, experiments -- concepts made tangible.

Perhaps the most important function of informal educational media is making education available to those who are no longer in school. Most of our population is out of school, with no further access to formal education. Museums are a significant mechanism for continuing education.

Thus, it is clear that museums, in and of themselves and as a complement to formal educational systems, constitute a major national resource for public education. Institutions of formal education devote significant resources to research on the development of effective curricula, materials, and teaching strategies. Museum research is costly in terms of time, money and personnel. Moreover, the field is likely to progress very slowly if only a handful of researchers are involved. Yet, it is only through such research that the answers to basic questions about communicating by means of exhibits can be found. Can museums, especially science museums, afford not to support educational research and evaluation designed to improve the effectiveness of their informal education devices, techniques, and programs?

Someday the child who plays with colored shadows in a science museum will have a flash of insight when he learns about primary colors in school. Someday the student experimenting with a Gravity Tower will decide to become a physicist. Someday a person who sees an exhibit on energy options will vote in a nuclear power referendum. Dare we continue to remain ignorant of the mechanisms at work in this important investment in the richness of our environment and the background of our judgment?

JOEL N. BLOOM
Vice President and Director
The Franklin Institute
Science Museum and Planetarium

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I. INTRODUCTION

The role of explanatory labels, or printed text on or near museum displays, is one of the most debated issues in museum circles. In fact the question of whether labels even belong in an exhibit often arises. Some museum professionals believe that labels detract from the direct experience of an artifact. This position is argued by Duncan Cameron who states that "effective communication between exhibitor and visitor remains dependent on the ability of the visitor to understand the nonverbal language of 'real things.'"[1]

Those who hold the opposite view contend that the creative use of printed materials is essential in order to communicate information and concepts to a diverse audience[2] and assert that through printed information the visitor learns "the language of museums, [which is] . . . learning to see real things, museum things . . . in the varied cognitive frameworks of scientific and historical knowledge."[3]

Findings from recent research on cognition[4] seem to support the widely held belief that:

> Objects (and other nonverbal visual aspects of the gallery setting) can communicate with the visitor on the affective level, and to some degree, on the

intellectual level as well. Labels and other printed material are considered as means of reinforcing, clarifying or conveying additional information to the visitor.[5]

In part, concern over the role of labels has undoubtedly arisen because of their historic misuse. Instances abound of museum exhibits containing incomprehensible or illegible labels. Early studies on museum label-reading indicate that under such conditions, little of the printed material receives visitors' attention.[6] Recent decades have witnessed a stylistic shift in exhibitry from a dimly-lit clutter of specimens with lengthy printed descriptions, to a carefully designed environment displaying a few objects with a minimum of written material. The trend away from using words in exhibits is based on an intuitive rather than a systematic, research-based approach to exhibit design. Even in those rare instances where research findings have been used as a rationale for design decisions, the data are often incomplete or obsolete. Since new methods for examining and assessing visitor behavior in general and measuring museum-based learning in particular have been developed, careful investigation of the communicative role of explanatory text in museum education is warranted.

As more detailed data on label-reading in museums become available, it is hoped that these findings will be used in making specific labeling decisions and will provide a research framework within which individual museums can develop their own labeling policy. Ultimately, this research framework will be most helpful if it is not the only determinant of policy. As one researcher points out:

> Research shouldn't replace editorial judgment, only narrow the uncertainty of such judgment. Nor should the findings limit creativity; rather, they should serve as a guide and safety device to help [a label-writer or] an editor prevent blunders.[7]

The investigations discussed in this report deal with visitor behavior in a science-technology museum whose exhibits provide for visitor interaction. However, the experimental methods and major findings may well be applied to many other informal learning environments which use constructed displays for teaching purposes.

The goal of this project was to assess current beliefs about label-reading in museums and to test the hypothesis that textual material reinforces and translates an interactive learning experience into measurable cognitive gains. Experiments were conducted to determine:

1. whether or not visitors choose to "study" the content of specific exhibits during their visit and if so, the relationship between this and other visitor behaviors;

2. what kind and length of explanatory label produces a significant increase in visitors' understanding and enjoyment of a display.

The following is an outline of the investigations discussed in detail in this report:

1. The Whole Visit Study--Adult visitors were tracked throughout their museum visit; their participation with displays and label-reading were observed.

2. The Transfer of Misinformation--Adults with children, who visited the Gravity Tower display when it was unaccompanied by explanatory text, were closely observed to determine whether the unlabeled display provided an occasion for the exchange of inaccurate information.

3. Preliminary Labeling Study--Visitors' interaction with an unlabeled and labeled display was compared.

4. Label Presence, Content, and Length Experiments--Questionnaires were administered to adult visitors to determine how variations in kind and length of explanatory label affect visitors' understanding and enjoyment of a display.

5. Children's Explanatory Label Experiment--Four format variations of a children's label were tested to determine which would increase the label's ability to attract greater numbers of young readers.

II. THE WHOLE VISIT STUDY

How do adult visitors to a science museum distribute their time? Is the amount of time they spend at individual exhibits fairly uniform throughout their visit or is it divided disproportionately? Does a relationship exist between the amount of time spent at an exhibit and other visitor behaviors, such as the extent of participation with displays or the amount of explanatory material read?

While some research has been done on these questions, most studies of exhibit utilization focus on a single exhibit hall or gallery rather than visitors' behavior throughout a museum visit. The available research data indicate that, on the average, few museum visitors read explanatory labels and that they spend little time during their visit reading labels.*

The Whole Visit Study was designed to extend this data and to test the hypothesis that during the course of a

*In observations of adults reading labels, Edward Robinson, a professor of psychology at Yale University, found that "of those persons who stopped to view a given exhibit approximately one in ten read at the label . . . On the average about one-tenth of the label was read by the one person in ten who read it." Edward Robinson, "Psychological Problems of the Science Museum," Museum News 8, No. 5 (1930):11.

museum visit, visitors will simply browse through most exhibit halls, but will also come upon one or more exhibits that hold their attention, in which they spend a significantly longer amount of time and read more labels. If the hypothesis proved correct, the research practice of documenting label-reading in terms of the average number of visitors reading a label or labels, or the average time spent reading labels during a visit would obscure significant differences in visitor behavior from one exhibit to another.

A. Definitions

Below are some definitions of terms as used in discussion of the Whole Visit Study and throughout this report:

1. Exhibit--a room (or hall) having a unifying theme and containing a group of displays

2. Display--"an enclosed glass case, a participatory device, or a panel or set of panels concerning a single topic and having uniform design treatment"[1]

3. Browsing--"Casual inspection of exhibits, unfocused looking [that is] normally accomplished while walking through a hall, until something is reached that commands full or partial engagement"[2]

4. Studying--spending more than an average amount of time involved with an exhibit. An exhibit is considered studied by a visitor when the time the visitor spends is more than the mean plus one standard deviation of the time spent in (a) that specific hall by all subjects, or (b) in all halls

by all subjects.*

5. Time Spent--the total time spent at displays in an exhibit hall as opposed to lapsed time in the hall. This measure represents only that time during which the visitor was observed to be involved with and held by the exhibit and excludes unrelated behavior occurring in the room.

B. Methods

Subjects for this study were randomly selected adults (19 years of age or older), with or without accompanying children, visiting in groups of two or more. Only the behavior of the selected member of each group was recorded. Since the study was intended to provide information on the behavior of people whose visits are self-directed, organized groups of children and adults (e.g., school, church, scout groups) whose itinerary is either the leader's choice or a collective decision, were excluded from the sample.

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*Since all visitors in our sample had peak times in one or two exhibits (regardless of how little actual time is represented by these peaks) it was necessary to have some collective measure of a "studied exhibit" which would exclude small peaks. The two measures (described above) were needed to define the threshold for "studied exhibits" because two variables influence this threshold: (1) time spent by individuals in an exhibit hall, and (2) size and complexity of an exhibit hall. The first measure, mean time spent in a specific hall by all subjects, includes those exhibits which, because of their smaller size, or the fact that they contain fewer displays, require a significantly shorter period of time to "study." The second measure, mean time in all halls, includes those exhibits in which some visitors spend significantly more time than in other exhibits but for which the average time has been inflated by one or a few visitors.

Potential respondents were approached just after they had paid their admission fee. Basic demographic information was recorded. With the subject's permission, the interviewer observed him or her as unobtrusively as possible throughout the entire visit (see figure 1). Visitors were asked to proceed as if the observer were not present. Participants were told that they would receive free readmission passes at the end of their visit.

A small sample of weekend visitors was used to test the survey forms and behavioral coding procedures. On the basis of these pilot study results, the procedure was revised and a random sample of 25 visitors was selected for intensive observation. Interviewers recorded the following information on floor-plan maps of each exhibit: the time the visitor entered and left the exhibit hall, the total amount of time spent at each display, whether or not the visitor appeared to read the display label* (if the display was labeled), and whether or not the visitor interacted with the display. Visitors were interviewed at the conclusion of their visit to determine their reactions to being observed and their explanations, if any, for their selection of particular exhibit halls for special attention.

C. Results

It was found that 76% of the visitors in the sample

*A visitor who looked at a label for two seconds or more was considered to have read the label.

Figure 1. Unobtrusive Observation During Whole Visit Study

selected certain exhibit halls to study. With respect to label-reading, while visitors read only 18% of the total number of labels available at all displays in the exhibit halls they visited, they did in fact read 68% of the labels on the particular displays at which they stopped.

Further, the average number of labels read in studied exhibits (7.75) is 2.4 times greater than the average number of labels read in browsed exhibit halls (3.23). The amount of interaction is also higher in studied exhibits. The average number of interactions with displays in studied halls (3.44) is almost twice as great as in browsed halls (1.78).

There was great variation in the choice of exhibit halls studied. Of the 21 halls in the museum, 20 were chosen for study by at least one visitor. Thus, this choice cannot be attributed solely to the attractiveness or excellence of a particular exhibit. Further, only 20% of the exhibits that visitors studied were halls that they had planned to see before coming to the museum. The remaining 80% were spontaneous discoveries. The exhibits that engaged sampled visitors covered nearly the full range of the museum's offerings, indicating the diversity of visitors' preferences and reactions.

An obvious concern in using the procedure described was that the presence of the observer would somehow influence visitors' behavior. While it cannot be said that there was no such influence, most subjects said that they did not notice the observer, and that the technique used did not detract from their enjoyment of the visit. No member of the sample offered any negative reaction to being observed.

D. Implications of the Study

Results of the Whole Visit Study support the hypothesis that during the course of a museum visit, most people study one or more exhibits. That is, they spend significantly more time at displays in these exhibits, read a significantly larger number of labels there, and interact with the displays more frequently than in exhibits they browse through. Visitors' selection of exhibits for study had more to do with individual interests than with the quality of the exhibit. Further, while it is impossible for visitors to attend to all the displays and read all the labels in a large museum during the course of an average two- to three-hour visit, they do, in fact, read an average of 68% of the labels on the displays at which they stop.

These findings strongly suggest the need for effective labeling of museum exhibits and for further research on exhibit labeling. What kind and length of printed explanation do visitors prefer? Do labels facilitate museum-based learning? Can they effectively encourage experimentation and speculation?

Such questions are the subject of a series of investigations conducted at the Franklin Institute Science Museum from October 1977 through April 1979. A description of these experiments and their results follows.

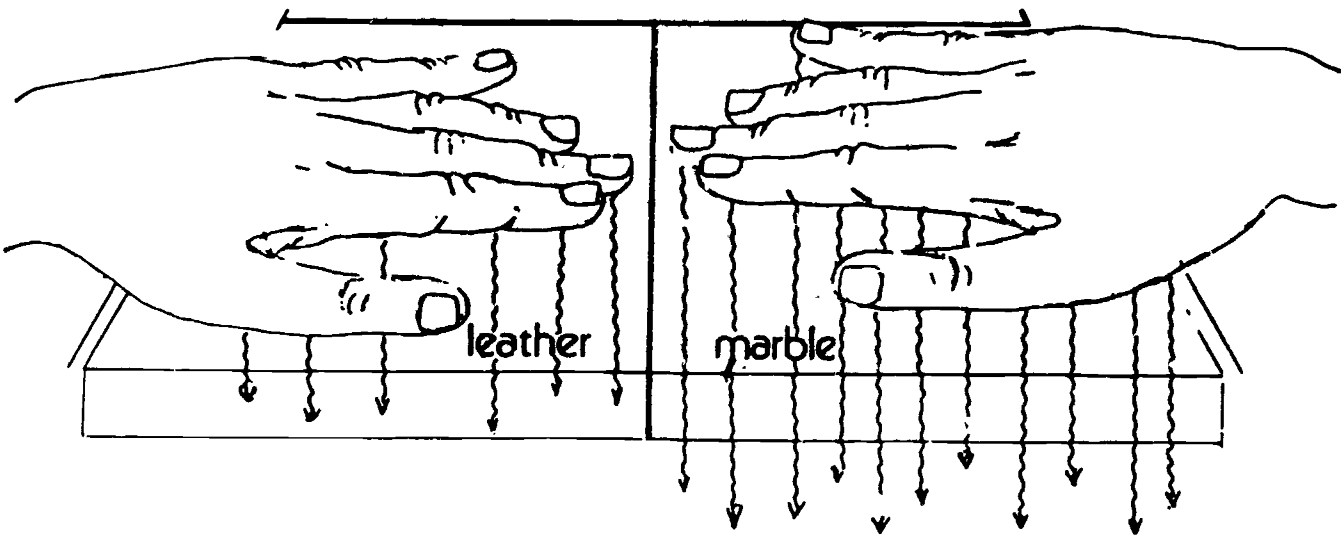
III. PRELIMINARY LABELING STUDY

A brief preliminary study was conducted to determine whether an explanatory label can effectively encourage meaningful experimentation with a participatory display. The display chosen for testing was a thermoconductor located in the Energy Exhibit. The objective of the display is to allow a visitor to explore the differences in apparent temperature of four different materials having the same actual temperature. This objective can only be met by tactile comparison of the materials.

Visitor behavior was compared when the display was labeled and not labeled (see figure 2). Random samples of visitors were observed under each of these conditions. The researcher recorded the number of visitors who viewed the display and (1) did not touch it, (2) touched or tapped only one of the four materials, or (3) compared two or more materials by touching (see table 1).

Results show that 78% of the visitors sampled made comparisons of the materials when the display was labeled as compared to 6% when it was unlabeled. Thus, it seems that the presence of an explanatory label can encourage the visitor to experiment with a participatory display in a way

All the squares are the same temperature, BUT...
Do they FEEL the same temperature?



The squares that feel cool take heat from your hands faster than those that feel warm.

Figure 2. The Thermoconductor Label

which produces a qualitative difference in his or her experience of it.

TABLE 1

PRELIMINARY LABELING STUDY

Visitor Behavior	Unlabeled Display (N = 50)	Labeled Display (N = 100)
Didn't Touch	72%	18%
Touched/tapped One	22%	4%
Made Comparison	6%	78%

IV. TEST SITE FOR LABELING STUDIES

The Energy Exhibit in the Franklin Institute Science Museum is a multisensory, interactive exhibit with minimal labeling and evocative rather than didactic printed material. The exhibit hall contains many simple, hands-on displays in a warm, colorful setting and is widely regarded as an excellent example of a "participatory" exhibit (see figure 3). Although the Energy Exhibit is quite popular, visitors' comments indicated a need for more and better explanatory labeling. The Energy Exhibit was selected as a "laboratory" in which to explore the impact of a label on visitors' enjoyment and understanding of displays, and to determine what kind and length of explanatory label best achieves these goals.

One display in the Energy Exhibit, the Gravity Tower, was chosen as the subject of intensive case-study, to test visitors' responses to a variety of experimental conditions. The Gravity Tower consists of a manually operated pump which, by creating an increasing volume and pressure of air under a small ball, pushes the ball to the top of a tall tube. The ball then rolls to the edge of a short ramp, falls twenty-five feet onto a large, slightly curved steel

Figure 3. The Energy Exhibit

plate, bounces from side to side on the plate in a series of decreasing arcs, and finally rolls into a hole at the center of the plate (see figures 4 and 5).

Figure 4. The Gravity Tower

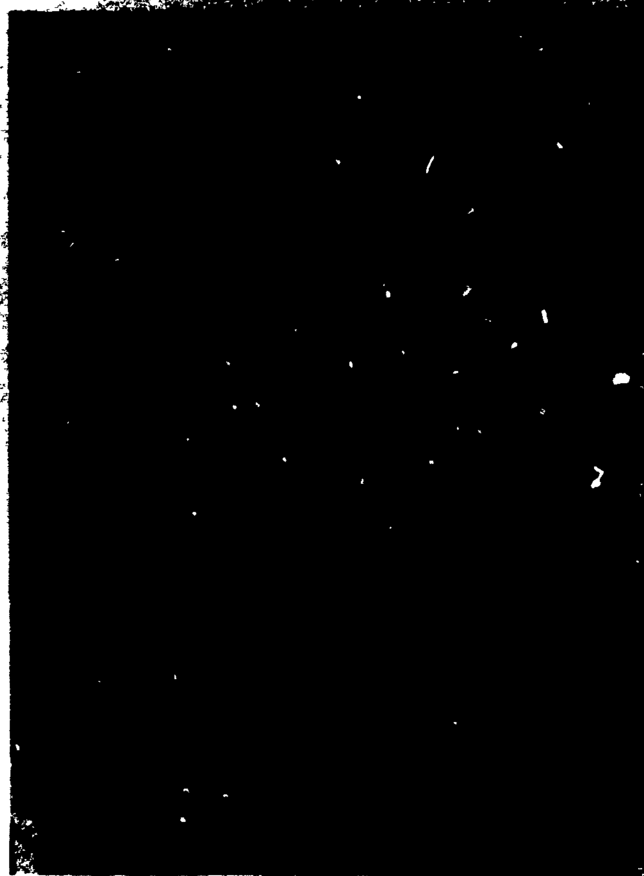


Figure 5. Operating the Gravity Tow

V. THE TRANSFER OF MISINFORMATION

A researcher standing unobtrusively among visitors to the Gravity Tower observed the behavior of adults and children in order to test the hypothesis that exchanges of misinformation occur when adults attempt to answer children's questions about an unlabeled display.

Frequent exchanges of inaccurate information about the operation of the unlabeled Gravity Tower were heard. For example, when asked why the ball didn't fall off the plate, one adult remarked that it "has something to do with the sound" of the plate rather than the shape of it. Another described the ball as bouncing "exactly the same way every time," rather than in a series of decreasing arcs. A third adult explained that the ball rolls into the hole in the plate "because there is a magnet in the middle pulling it down" rather than because the ball has insufficient energy to overcome the pull of gravity.

While the above was based on spot observations and not systematic sampling, these anecdotes do suggest that without explanatory labels, science museums provide occasions for misinforming or confusing rather than educating visitors.

VI. LABEL PRESENCE, CONTENT, AND LENGTH EXPERIMENTS

Experiments were conducted using the Gravity Tower as a case-study to determine what kind and length of explanatory label visitors prefer and whether such a label can produce a significant increase in their enjoyment and understanding of the display. An explanatory label for the Gravity Tower was written and designed expressly for these experiments (see figure 6). Requirements for the content of the label were that it: (1) relate scientific principles to the experience offered by the display, (2) include other information of potential interest to visitors, and (3) be segmentable for label content and length experiments.

Open-ended interviews in which visitors were asked to describe how the Gravity Tower works were conducted in order to determine the amount and level of understanding visitors had of the unlabeled display. While many visitors were able to accurately describe what they saw (e.g., the path of the ball), few responses included allusions to pertinent, but less tangible concepts such as air pressure or gravity.

Figure 6. Text ot Summary Label

THE GRAVITY TOWER

HOW IT WORKS: ENERGY CONVERSIONS

When you press the pump, the chemical energy in your muscles is transferred to the mechanical energy of the pump which compresses air under the ball, raising the ball and increasing its potential (positional) energy.

As the ball falls, "gravity" (a pull towards the earth's center) causes the ball to fall faster and faster, changing the ball's potential energy to kinetic (moving) energy.

The ball cannot transfer much of its energy to the plate, so it bounces back into the air, changing its kinetic energy back into potential energy.

Then gravity pulls it back down, converting the energy to motion again. Each bounce of the ball is a little less high because some of the energy has been lost. Finally, the ball rolls into the hole at the center of the plate.

ENERGY LOSSES

You put energy into the system to raise the ball; but when the ball comes to rest at the bottom of the tube, it has no energy. With each energy transfer, some energy is lost as heat. Energy is lost through "friction" (rubbing) in the pump. A small amount of energy is lost by the ball when it rings the bell. As the moving ball pushes through the air, it loses energy through friction of the air against the ball ("air resistance"). Some energy is lost each time the ball strikes the plate. Finally, it stops bouncing and rolls into the hole.

ENTROPY

With each energy transfer, some of the ball's useable energy is lost as heat. This illustrates the "Law of Entropy." In general, the amount of useable energy in the universe is decreasing; that is, "everything runs downhill."

A familiar example of the principle of entropy is winding a wrist watch. You put energy into the watch as you wind it and this propels the hands of the watch. Gradually, the watch loses its energy and must be re-wound. Pin-ball machines and wind-up toys are other devices that illustrate entropy.

THE BALL'S PATH

When the ball falls from the tube, gravity pulls it down to the plate. Since the surface of the plate is slightly curved, the ball bounces from side to side in a series of arcs of decreasing height. Sometimes, this pattern is broken when tiny dents in the surface of the ball and plate and pieces of dust on the plate, the rims of the plate and of the hole, change the angle at which the ball hits the plate or even cause the ball to bounce off.

GRAVITY

The first scientific experiments on gravity were made in the 16th century by Galileo Galilei, who studied balls rolling down curved ramps. He discovered that objects fall faster and faster as they descend. This is called the "Law of Gravity." Isaac Newton continued this work by studying the paths of falling, rising, and flying objects. Newton's findings have been applied in the fields of gunnery, ballistic missiles, and baseball.

The interviews and the recorded exchanges of misinformation were used as a basis for writing the summary explanatory label for the Gravity Tower. The label contained the following information:

1. how the display works,
2. the scientific principles illustrated by the display,
3. relevant historical material, and
4. everyday applications of principles demonstrated by the display.

Label text was edited and revised by members of the Museum's Education and Evaluation Departments.

Existing research on typography, color, illustrations, and lay-out served as guidelines for the physical characteristics of the explanatory labels used in the investigations. While the majority of studies of factors affecting the readability of printed information deal with books and newspapers, some of the results appear applicable to the explanatory labels associated with museum exhibits. For an outline of relevant findings, see Appendix A.

In order to be certain that visitors sampled for cognitive testing would be able to understand the summary label, its age-appropriateness was determined. Using the CLOZE procedure (see Appendix B), the comprehensibility of the summary label was tested for each of four age groups: 11 to 14, 15 to 18, 19 to 22, and 23 or older, on a sample of 25 visitors for each group. A CLOZE score of 57% or more is considered full comprehension.[1] As shown in table 2, scores indicate that the summary label was not comprehensible to 11 to 14 year olds, but was fully comprehensible to visitors aged 15 years or older.

Although the CLOZE procedure indicated that the summary label was fully comprehensible to age fifteen and above, the process of pilot-testing the summary label revealed that it was very difficult to find label-readers in the 15 to 18 age group. Consequently, adults aged 19 years or older wer targeted for the labeling experiments.

TABLE 2

CLOZE SCORES FOR SUMMARY LABEL

Age	N	Mean Score
11-14	25	30%
15-18	25	65%
18-22	25	70%
23 and older	25	72%

The basic sampling and testing procedure was identical for the label presence, content, and length experiments. The interviewer chose a spotting point near the Gravity Tower that visitors would need to pass if they were going to watch and/or interact with the display. The first visitor who passed this point was observed at the display, and approached upon leaving the display. The data collector introduced herself as a member of the museum staff and asked the visitor if he or she would be willing to answer some questions. The potential respondent was asked several screening questions to ascertain whether he or she (1) was 19 years of age or older, (2) was seeing the Gravity Tower for the first time, and (3) looked at the display rather than being primarily involved in unrelated behaviors such as wandering. Those who met these criteria and agreed to participate in the study were directed to a table in the corner of the exhibit hall where they filled out a written questionnaire and quiz (see figure 7). The questions elicited visitors' cognitive and affective responses to the display and pertinent demographic information, including the respondent's age, sex, level of education, and school major (see Appendix C). Each respondent received a token gift for participating in the experiment.

A. Label Presence Experiment

This experiment was designed to determine whether the presence of a five-paragraph summary explanatory label, associated with the Gravity Tower, affected the amount of information visitors received from the display (cognitive score) and how visitors felt about the display (affective response).

Figure 7. Respondent Completing Questionnaire during Label Presence Experiment

The sample consisted of 100 randomly selected adult visitors, 19 or more years old, who were seeing the Gravity Tower for the first time. The 50 treatment group subjects were visitors who saw the display with the explanatory label and had read the label. The 50 control group subjects viewed the unlabeled display.

Results

A two-tailed t-test indicates that significant differences exist between the test scores of the treatment and control groups, suggesting that an explanatory label can increase learning from the display.

TABLE 3

LABEL PRESENCE EXPERIMENT
T-TEST OF COGNITIVE TEST SCORES BY TEST GROUP

Test Group	N	Mean Cognitive Test Score (% correct)	t	Level of Significance (α)
Control	47	54.93	3.16	0.01
Treatment	48	68.18		

The treatment and control groups were statistically compared to determine whether they were similar in terms of visitors' sex, level of education, and science background (i.e., majored in science or did not). Results, as shown in tables 4 and 5, indicate that the groups were equivalent in terms of sex and educational level of the subjects. However, as can be seen in table 6, there was a significant difference between groups in the number of science majors. Further, science background was responsible for a significant amount of the variance in the respondents' cognitive test scores.

TABLE 4

LABEL PRESENCE EXPERIMENT
GENDER OF SUBJECTS

Test Group	N	Male		Female	
		Number	Percentage	Number	Percentage
Control	47	24	50	23	50
Treatment	48	21	44	27	56

TABLE 5

LABEL PRESENCE EXPERIMENT
EDUCATIONAL STATUS OF SUBJECTS

Test Group	N	Highest Grade Completed					
		High School Graduate or Less		Some College to College Graduate		Some Graduate School or More	
		Number	Percentage	Number	Percentage	Number	Percentage
Control	46	14	30	28	61	4	9
Treatment	48	14	29	27	56	7	15

TABLE 6

LABEL PRESENCE EXPERIMENT
SCIENCE BACKGROUND OF SUBJECTS

Test Group	N	School Major			
		Science		Not Science	
		Number	Percentage	Number	Percentage
Control	47	7	15	40	85
Treatment	48	19	40	29	60

It was found that the mean test score of treatment group subjects with a science background was essentially the same as that of control group subjects with a science background; however, the scores of treatment group subjects without a science background were significantly higher than those of control group subjects without a science background (see table 7).

TABLE 7

LABEL PRESENCE EXPERIMENT
T-TEST OF COGNITIVE TEST SCORES BY SCIENCE BACKGROUND

Test Group	N	Mean Cognitive Test Score (% correct)	t	Level of Significance (α)
	Subjects with Science Background			
Control	7	80.52	0.02	N.S.
Treatment	19	80.38		
	Subjects without Science Background			
Control	40	50.45	2.12	).05
Treatment	29	60.19		

Apparently, visitors with a science background are already familiar with the material being tested but are, nevertheless, more likely to read the explanatory label. Visitors who do not already know this material do learn from the label.

Respondents were also asked to select from a twenty-word list of adjectives those words which best describe the display (see table 8). When the responses of the treatment and control group were compared, it was found that five words showed at least a 10% change in frequency: informative (up 45% over control), useful (up 18%), pleasing (up 17%), helpful (up 14%), and imaginative (down 12%). However, only the change in the selection of the word "informative" is statistically significant.*

B. The Label Content Experiment

This experiment was conducted to compare the effects of each of four labels with varying content, associated with the Gravity Tower, on visitors' cognitive scores and affective response in order to determine what type of label content, if any, is most effective in terms of these criteria.

A random sample of 200 adult visitors 19 years old or older, who were seeing the display for the first time, was selected. The sample consisted of four subgroups;

*$\phi = 0.46$

TABLE 8

LABEL PRESENCE EXPERIMENT
FREQUENCY OF SELECTION OF ADJECTIVES

Adjective	Control Group		Treatment Group	
	Number	Percentage	Number	Percentage
Attractive	20	41	18	37
Average	1	2	2	4
Dull	1	2	0	--
Entertaining	35	71	35	71
Exciting	5	10	8	16
Difficult	1	2	0	--
Fascinating	18	37	17	35
Friendly	10	20	6	1
Fun	28	57	29	59
Helpful	1	2	8	16
Imaginative	27	55	21	43
Impressive	9	18	10	20
Important	1	2	3	6
Confusing	0	--	0	--
Informative	11	22	33	67
Interesting	3[illegible]	69	33	67
Irritating	0	--	0	--
Pleasing	11	22	19	39
Unclear	4	8	2	4
Useful	3	6	12	24

each viewed the display when it was labeled with one of four components of the original summary label:

Label 1: How It Works

Label 2: Science Principles

Label 3: Historical Information

Label 4: Everyday Applications

Each label remained on the display until a sample of 50 randomly selected adult visitors who had read the label was tested.

The questionnaire and quiz used in these tests was similar to that used in the label presence experiment but contained only those questions pertaining to the information in the component label. When the questionnaire was completed and collected, each respondent was handed copies of the four component labels and was asked to read them and to indicate the one that he or she considered most appropriate for the display. Respondents received the preference sheet at this time so that they could not refer to the label they had read and alter their answers to quiz questions.

The demographic characteristics of visitors in each of the four test groups were statistically tested to ensure that there were no significant differences in the populations. It was found that the test groups were similar in terms of the visitors' sex, level of education, and science background.

Results

Subjects' cognitive scores were measured and compared to control group scores for each of the four labeling conditions. The figures in table 9 show that quiz scores increased for all of the labels. The greatest increases in scores are seen with labels containing historical information and everyday applications. Much lower gains are found with labels explaining scientific principles and how the display works. However, when visitors were asked to select the label they preferred for the Gravity Tower, the reverse was found. "How it Works" and "Science Principles" were far more popular than "Historical Information" and "Everyday Applications" (see table 10). No significant differences were found on the adjec- checklist.

The only conclusion which seems apparent from this data is that, since all of the label content produces significant cognitive gains, none can be eliminated on this basis alone. While the discussions of how the display operates and the scientific principles involved are far more difficult for visitors to understand and thus yield lower cognitive gains, this material is clearly desired by visitors and appropriate in a science museum label.

TABLE 9

LABEL CONTENT EXPERIMENT
T-TEST OF COGNITIVE GAIN SCORES BY TEST GROUP

Label	Control Group		Treatment Group		Gain	t	Level of Significance (α)
	Mean Test Score (% correct)	N	Mean Test Score (% correct)	N			
How it Works	73.05	47	87.75	49	14.70	2.65	0.02
Science Principles	51.06	47	68.00	50	16.94	3.54	0.001
Historical Information	42.55	47	92.00	50	49.45	6.09	0.001
Everyday Applications	43.62	47	85.00	50	41.38	7.05	0.001

TABLE 10

LABEL CONTENT EXPERIMENT
VISITOR PREFERENCES

Label	Number of Visitors	Percentage of Sample
How it Works	87	46
Science Principles	63	33
Historical Information	24	13
Everyday Applications	15	8

C. Label Length Experiment

The final phase of this section of the study was intended to determine what length of label is most effective in terms of visitors' cognitive scores and affective response.

The sample consisted of 125 visitors in five experimental groups, each containing 25 randomly selected adult subjects. Respondents in each of the test groups were visitors who had read one of five test labels associated with the Gravity Tower. Test labels for this experiment were components of the original summary explanatory label, arranged in sequential topics. Topics varied in length from 7 to 14 lines of text with an average of 48 characters per line, including spaces (see table 11).

TABLE 11

LABEL LENGTH EXPERIMENT
TOPICS AND LENGTHS

Label		Lines of Text
Topic 1:	How it Works	14
Topic 2:	Science Principles--1	7
Topic 3:	Science Principles--2	8
Topic 4:	Historical Information	9
Topic 5:	Everyday Applications	7

The first topic consisted of 14 lines of text. Topics two through five ranged from 7 to 9 lines of text. The number of topics on the label increased by one with each experimental condition. The first test group consisted of visitors who saw topic 1, the second group topics 1 and 2. For each remaining test group, label length was successively increased by one additional topic.

The content of the written questionnaire was similar to that used in the Label Presence and Label Content experiments except that questions pertaining to portions of the original summary label that were not available to visitors in a specific test group were not included in the quiz for that test group. When visitors had completed the questionnaire and quiz, they were handed a photocopy of the original summary label and were asked to indicate how much of the label they had read and how long they thought the label ought to be. The five test groups were statistically compared to ensure that there were no significant differences in the populations.

Results

All of the component labels produced cognitive gains, which were statistically significant for all but the three-topic label. The greatest gain was associated with the two-topic label (see table 12).

In terms of the length of text actually read by visitors, the proportion of visitors who read the entire label decreased as label length increased. There is a sharp decline in readership of the whole label between the one-topic and two-topic labels and between the two-topic and three-topic labels. The first two labels (14 and 21 lines of text) were completely read by a majority of the tested sample. The longer labels were read in their entirety by a much smaller proportion of the sample (see table 13).

Further, while the average number of lines of text read increased as the length of the label increased, the average portion of the label read decreased (see table 14).

TABLE 12

LABEL LENGTH EXPERIMENT
T-TEST OF COGNITIVE GAIN SCORES BY TEST GROUP

Label	Control Group		Treatment Group		Gain	t	Level of Significance (α)
	Mean Test Score (% correct)	N	Mean Test Score (% correct)	N			
1 Topic	73.05	47	87.75	25	14.70	2.65	0.01
2 Topics	77.13	47	92.00	25	14.87	2.81	0.01
3 Topics	69.86	47	79.86	24	10.00	1.85	N.S.
4 Topics	57.45	47	69.45	24	12.00	2.23	0.05
5 Topics	54.93	47	68.18	25	13.25	3.16	0.01

TABLE 13

LABEL LENGTH EXPERIMENT
FREQUENCY OF READING WHOLE LABEL

Label	Lines Available	Visitors Reading Whole Label		Visitors Reading Less Than Whole Label	
		Number	Percentage	Number	Percentage
1 Topic	14	20	91	2	9
2 Topics	21	13	65	7	35
3 Topics	29	8	38	13	62
4 Topics	38	4	17	20	83
5 Topics	45	3	12	22	88

TABLE 14

LABEL LENGTH EXPERIMENT
PORTION OF LABEL READ

Label	Lines Available	N	Average Number of Lines Read	Average Portion of Label Read
1 Topic	14	22	13	93%
2 Topics	21	20	17	81%
3 Topics	29	21	20	69%
4 Topics	38	24	22	58%
5 Topics	45	25	22	49%

With regard to affective response, none of the experimental labels showed significant differences between treatment and control groups for visitors' choices from the twenty-word adjective list. In terms of visitors' stated preferences, the weighted average length of text preferred* is approximately 30 lines rather than a shorter explanation. However, people seemed to select a preferred length that corresponded somewhat to the length of the label they had seen. For the first two labels, the average preferred length visitors picked was four lines longer than the text the subjects saw, for the third and fourth, it was one line longer. Only in the case of the 45-line label was a shorter label preferred (see table 15).

TABLE 15

LABEL LENGTH EXPERIMENT
LENGTH OF TEXT PREFERRED BY VISITORS

Label	Lines Available	N	Average Number of Lines Preferred
1 Topic	14	14	18
2 Topics	21	20	25
3 Topics	29	17	30
4 Topics	38	20	39
5 Topics	45	25	35

*Weighted average =

$$\frac{\Sigma \text{ (number in group reporting preference} \times \text{average lines preferred)}}{\text{total number reporting preference}}$$

As in the case of the Label Content experiment, there is a disparity between visitors' stated preferences and their actual behavior. Visitors prefer approximately 30 lines of text (three topics), but the majority of the sample read the entire label only when it consisted of 21 or fewer lines of text (one or two topics). From these data some rough guidelines for the length of an explanatory label can be drawn. If the goal is to reach a majority of the potential label-reading adult audience, about 21 to 30 lines of text on two to three major topics seems to work well (assuming the text is readable and comprehensible to this visitor population). Additional text, while desirable in some instances, will have a far more limited audience.

VII. CHILDREN'S EXPLANATORY LABEL EXPERIMENT

The investigations described above established that adult visitors read labels in exhibit halls they elect to study and documented that visitors show cognitive gains as a result of label-reading. Obviously, the museum audience is not composed only of adults. In fact, children are often a major portion of the audience. Since the museum serves as an adjunct to other educational resources for children, it seems important to consider the impact of explanatory labels on young visitors.

Experience in the Preliminary Labeling Study and in pilot-testing the summary label indicated that few children read labels. This is not to say that our attempts at explanation failed to reach children, since parents were often observed reading or explaining labels to their children. The following is a discussion of a series of attempts to increase the number of children who read explanatory labels.

For the children's label experiment, an explanatory label for the Gravity Tower was written on the basis of the results of the Label Content and Label Length experiments. The label contained two topics and 21 lines of text giving information on how the display works and science principles involved (see figure 8). This label was tested and revised to ensure that it would be comprehensible to a young audience. Four format variations were then tested to see if any or all of these would increase the label's ability to attract young readers.

The children's label was tested for comprehensibility on a sample of 70 children between the ages of 8 and 14. Young visitors were randomly sampled and the age, grade and sex of participants were recorded. Respondents were given a copy of the label and were asked to read it. After they read it, the children were asked, "Do you understand what you just read?" and were instructed to underline anything on the label that was unclear. In addition, a group of third through ninth grade teachers read the label and were asked, "Do you feel that your students would be able to read and understand this label?" Their responses were used as a basis for editing the label text, which went through three stages of revision. A CLOZE test of reading grade level was then administered to a random sample of 25 visitors ages 8 to 14 years old. The average CLOZE score, 70%, indicates that the revised text is fully comprehensible to this age group.

The sample for the children's label experiment consisted of 150 randomly selected visitors between the ages of 8 and 14. The control group was composed of 30 subjects who visited the display bearing plain text. The treatment

Figure 8. Text of Children's Label

THE GRAVITY TOWER

HOW IT WORKS

When you push on the pump, the energy from your work makes air push the ball up the tube. As the ball moves up it gets more energy. This energy is called potential (po-ten-shul) energy.

Gravity (grav-i-tee) is a force from the center of the earth which pulls things towards it. As the ball falls, gravity makes it fall faster and faster and the ball's potential energy changes into moving energy. Moving energy is called kinetic (ki-net-ik) energy.

Each time the ball bounces up from the plate, it bounces less high. You put energy into the ball, but each time the ball hits the plate and even as it rubs against the air, some of its moving energy turns into two other kinds of energy - heat and sound. When the ball has lost most of its energy, it rolls into the hole at the center of the plate.

THE PATH OF THE BALL

If the plate were flat, the ball would bounce on one side of the center hole in the plate. But the plate is really a little curved. This makes the ball bounce from one side to the other. Often the ball bounces this way, but sometimes it hits a tiny dent in the plate or a piece of dust or even air moving past, which can make the ball bounce off the plate.

group consisted of four subgroups of 30 children. Each subgroup saw the display bearing one of the following variants of the basic label:

1. label containing an explanatory diagram,
2. label surrounded by a colored border,
3. label containing a picture of a "Star Wars" character (R2D2), or
4. composite label with all three of the above features.

A test of the attracting power of the children's labels was cond' ced to discover which of the label variants was most successful in engaging the attention of young visitors. Children visiting the Gravity Tower were observed and a record was kept of whether or not each subject read the explanatory label. When the subject appeared ready to leave the Energy Exhibit, the data collector asked and recorded his or her age. This procedure was used for each of the experimental conditions.

Results

None of these format variations, including the composite label, attracted a significantly larger group of young readers than did plain text (see table 16).

The results of the children's explanatory label experiment indicate that the addition of a diagram, colored border, or popular fictional character does not increase the attracting power of printed labels. As was observed earlier, explanatory information seems to reach children primarily via their parents or adult escorts.

TABLE 16

CHILDREN'S LABEL EXPERIMENT
ATTRACTING POWER OF CHILDREN'S LABELS

Label	N	Label Readers	
		Number	Percentage
Plain Text	30	2	7
Diagram	30	0	0
Color Border	30	3	10
Character	30	0	0
Composite	30	3	10

VIII. SUMMARY AND CONCLUSIONS

The investigations discussed in this report represent a probe into the little known realm of museum research. Unlike museum evaluation, which uses similar techniques to improve an exhibit or measure its success in fulfilling the objectives of its creators, museum research attempts to uncover basic data about the way visitors experience exhibits. The study of effective exhibit techniques is a complex field; many factors can affect visitors' understanding of and response to a display. Explanatory text was chosen as the variable to manipulate in this series of studies for three reasons. First, labeling is a subject about which there is much debate, much disagreement and many questions, yet about which there is little research-based data. Second, the making of explanatory labels involves the joint effort of exhibit designers and museum educators, whose objectives, styles, and concerns are frequently in conflict. Third, a label, as a discrete part of a display, lends itself readily to manipulation and testing.

The first investigation, The Whole Visit Study, sought to determine whether visitors read exhibit labels.

By tracking adult subjects throughout their entire museum visit and recording their behavior, it was found that while visitors read an average of only 18% of the labels available to them in the exhibit halls they entered, they read an average of 68% of the labels on the displays at which they stopped. This suggests that if a display is able to attract and hold a visitor's attention, he or she is likely to read the label associated with that display. Supporting this observation is the finding that visitors read 2.4 times the number of labels and interacted with displays nearly twice as often in exhibits that held them as in exhibits through which they browsed. Thus, contrary to current belief, the average adult visitor does read labels.

Next, in the Preliminary Labeling Study, research was conducted to determine whether an explanatory label associated with a participatory display can affect the quality of visitors' interaction with the display. The display chosen, a thermoconductor, can only be understood if tactile comparisons are made. It was found that when the display was labeled, 78% of the visitors to it made such comparisons as compared to 6% when it was not labeled. This indicates that an explanatory label has the potential to significantly alter and improve the quality of visitors' experiences with a participatory display.

For the investigations which followed, one interactive display, The Gravity Tower, was the subject of intensive case study. By listening to conversations between adults and children at the display, we found that the adults were conveying misinformation when attempting to explain the unlabeled display. In the Label Presence experiment, adult visitors' cognitive and affective responses to the unlabeled and labeled display were compared. Results showed that visitors without a science background learned significantly more from the display when it was labeled than when it was not. Further, more visitors considered the display informative when it bore an explanatory label.

The Label Content experiment compared the effects of four different kinds of information, presented in labels, on visitors' cognitive and affective responses to the display. It was found that, while visitors learned more of the material in the labels which offered the historical background and everyday applications of the principles illustrated by the display, they preferred the more difficult material which described how the display works and the scientific principles it illustrates. The effect of the amount of text in a label on visitors' cognitive and affective responses to the display was studied in the Label Length experiment. Five labels of increasing length were tested. The results showed that a label containing 21 to 30 lines of text on two to three major topics seems to effectively reach a majority of the adult label-reading audience.

These findings suggest that an unlabeled display is likely to be misinterpreted and that an explanatory label can enhance the instructional effectiveness of a display. Further, visitors do not prefer information that is easy to understand, but want an explanation of how the display works and the scientific principles involved. Finally, a label of 21 to 30 lines of text (48 characters per line) is likely to be cost-effective in terms of readership.

In addition, it had been observed (although not quantified) that few children read explanatory labels. A simplified label was tested in five versions: unadorned; surrounded by a color border; embellished with a picture of a popular fictional character; illustrated with a diagram; and with the border, character and diagram combined. None of these strategies significantly increased the number of children who read the label.

Experimental research in museums is field research, involving the study of a system in its actual setting rather than in a laboratory. As in all field studies, it is difficult to hold constant the many variables that potentially affect the system under observation. External factors such as special occasions or promotional events, changing exhibits, and damage to displays are often beyond the researcher's control. The selection of one display for intensive case study minimizes these problems but increases the problem of generalizability. To find out how widely applicable our findings are, similar research must be carried out in other museum environments with different audiences.

All of the studies reported here suggest that explanatory labels will be read and appreciated by adult visitors and that careful attention to the wording, reading level, and length of the text can produce a label which significantly adds to visitors' understanding of a display. With regard to communicating with children, further research is needed, but our observations of the misinterpretation of an unlabeled display indicate that it is important to have labels which adults can understand and can read or translate to children.

Reading of the printed material accompanying a participatory display has been shown to reinforce and translate an interactive learning experience into measurable cognitive gains. Labels can convey information about the historical background and cultural impact of the scientific and technical developments displayed and can introduce or reinforce scientific principles illustrated by the display. Adult visitors pay special attention to labels in the exhibit halls which catch their interest. But, the halls which they choose to study are as diverse as the visitors themselves. It is thus important to have good explanatory material available in all exhibits. Rather than bemoaning the fact that visitors do not read all of the printed material available, it is the responsibility of museums to provide visitors with concise, intelligible explanations of displays.

Museum professionals, realizing that wealthy benefactors and substantial endowments are becoming increasingly rare, are turning more and more to public funds and admission fees for support. At the same time, competition for the public dollar has also been increasing; funds for informal education are sought by diverse institutions ranging from television to community centers. In order to gain substantial public support, an organization must do something which the public values. Museums' competitors for the public's attendance, such as Disneyland and Busch Gardens, do extensive research on both their market and their services. The time has long since passed when museums could simply open their doors and permit visitors a glimpse of their scarce and valuable treasures or allow them to stare in awe at technological wonders. If museums are to be more than antique repositories or funhouses, if they are to be effective centers of informal education, we must ensure that our exhibits and programs are attractive, informative, and comprehensible to our audiences. The studies presented in this report are intended as a step in this direction.

APPENDIX A

RESEARCH ON READABILITY OF PRINTED TEXT

The following guidelines for the effectiveness of printed text are drawn from a comprehensive research review compiled by Mary Anne Frenzel.[1] This synthesis of studies to date on readability served as a basis for the physical characteristics of the printed explanatory labels used in our labeling investigations.

1. Typography

Typeface has been found to have a significant effect on the readability of a passage of text. The most effective types are those which have a maximum amount of white space within the letter, avoid narrowing in letters such as "A," "V," and "Z" and which do not have hairline strokes for the middle horizontal of "E" and "F". Generally, serif type tends to be more readable than sans-serif. Reading speed is reduced when italic type or mixed typefaces are used. However, mixed upper- and lower-case letters are more readable than upper- or lower-case alone. Finally, too narrow or wide lines of print should be avoided; a useful rule to follow is: the length of the line in picas should not be more than twice the type-point size.

2. Color

Much of the research on use of color has focused on newspaper and magazine advertising and has shown that while the eye is drawn to color in a lay-out, color has a stronger effect on motivation than on learning. When color is used in publications, the printed material seems to make a more lasting impression on the reader. Though the addition of one color does not make a significant difference, four-color advertisements increase readership by 55% over black-and white versions. While the use of color in advertisements can boost sales by as much as 70%, the implications of this for the use of color in learning situations is unclear.

In studying the most legible combinations of print and background for poster boards to be read at a distance, it was found that the difference in brightness between print and paper is the single most significant factor influencing color legibility. Among the most legible print-background combinations are: blue-on-white, black-on-yellow, green-on-white, and black-on-white.

3. Photographs and Illustrations

Illustrations have been found to attract interest and help the reader remember and interpret the content of accompanying material. Research also shows that the reader's eyes are first drawn to the upper part of a layout. Since our eyes have a tendency to move down when reading a picture and seem to be inhibited when moving in an upward direction, it is better to arrange a layout with a picture above the copy rather than below it. If a picture is placed slightly above and to the left of the optical center of the page it can attract the attention of the reader and aid the normal pattern of eye movement on the page.

4. Lay-out

Increasing the amount of white space through the use of margins, indented paragraphs, windows, etc. makes the page appear easier to read and is an important consideration in the reader's selection of the message. Further, long columns should be broken up with various typographical devices, such as boldface lead-ins and subheads.

APPENDIX B

TESTING READING LEVEL

Several different methods were used to predict and then to measure the reading level of the explanatory text used in our labeling studies. These included the FORCAST readability formula, the SMOG grading formula, and the CLOZE procedure.[1]

The FORCAST formula and the SMOG grading formula, both of which generate reading grade level (RGL) scores, are computed using the following formulas:

$$\text{FORCAST RGL} = 20 - \frac{\left\{\begin{array}{c}\text{The number of 1-syllable words in} \\ \text{a 150 word passage}\end{array}\right\}}{10}$$

SMOG RGL = 3 + square root of the number of polysyllabic words in 30 sentences.

Using the FORCAST formula, the RGL of the summary label was found to be between ninth and tenth grade; with the SMOG grading formula it was that of a college senior. It is not unusual for predictive formulas such as the SMOG and FORCAST indices to yield such disparate reading levels for the same passage of text.

The CLOZE procedure is a direct, rather than predictive measure of reading difficulty; although more time-consuming, this measure permits the responses of visitors themselves to determine the clarity and readability of each passage and is thus a more accurate measure of comprehensibility than the predictive formulas.

The CLOZE procedure is performed by replacing every fifth word in the text with a standard-sized blank space, presenting this text to a sample of readers, and having each reader attempt to fill in the blanks. A variation of the CLOZE procedure is to employ all five possible versions in which every fifth word is deleted (that is, one version deleting words 1, 6, 11, . . . ; another deleting words 2, 7, 12, . . . ; etc.). The CLOZE score is the percentage of the blanks that are filled in with exactly the same word as had been deleted. An average CLOZE score of 57% or greater is indicative of full comprehension.

APPENDIX C

QUESTIONNAIRE

FOR OFFICE USE ONLY:	COLUMN #
ID # ☐☐☐☐	1-4
DATE ☐☐ ☐☐ ☐☐	5-10
DAY OF WEEK ☐	11
TIME OF DAY ☐	12
EXP. # ☐	13
TEST GROUP ☐	14

THE ENERGY EXHIBIT QUIZ

We are interested in finding out how well the displays in the Energy Exhibit teach and would like to know what people like you think about different aspects of the exhibit. Please read the following questions slowly and answer them carefully. Your responses will remain confidential and will help us make your museum visit more enjoyable.

Thanks very much for your time!

SOME QUESTIONS ABOUT YOU AND YOUR VISIT . . .

1. Was this the first time you'd seen the Energy Exhibit? 15

__ Yes

__ No

2. Look over this list of words and tell me which ones apply to the display pictured here. Pick as many as you like. 16-19

1. Attractive	11. Imaginative
2. Average	12. Impressive
3. Dull	13. Important
4. Entertaining	14. Confusing
5. Exciting	15. Informative
6. Difficult	16. Interesting
7. Fascinating	17. Irritating
8. Friendly	18. Pleasing
9. Fun	19. Unclear
10. Helpful	20. Useful

20-23

24-27

28-31

32-35

3. You are ______.

__ A. Male 36

__ B. Female

4. How old are you? 37-38

_____ years old

5. How far have you gone in school?

__ A. 8th grade or less

__ B. High School 39

__ C. College

__ D. Graduate or professional school

6. Did you major in science (or do you plan to)?

___ A. Yes

___ B. No

___ C. Maybe

___ D. Probably not

40

SOME QUESTIONS ABOUT THE DISPLAY . . .

7. What is the display pictured here called?

___ A. The Bouncing Ball

___ B. The Energy Island

___ C. The Friction Tube

___ D. The Gravity Tower

41

8. What pushes the ball up the tube?

___ A. Air

___ B. Steam

___ C. Gravity

___ D. A rod

42

9. What happens to the ball as it is raised up the tube?

___ A. It gets lighter

___ B. It gains kinetic energy

___ C. It gets heavier

___ D. It gains potential energy

43

10. As the ball falls ______.

___ A. It falls slower and slower as it nears the plate.

___ B. Its chemical energy changes to mechanical energy

___ C. Its potential energy changes to kinetic energy

___ D. Its kinetic energy changes to potential energy

44

11. Which of these does not rob the ball of energy?

___ A. Air resistance

___ B. The ball's electrical charge

___ C. Friction in the pump

___ D. The ball ringing the bell

45

12. When the ball comes to rest at the bottom of the tube ______.

___ A. It has no energy

___ B. It is charged with electrical energy

___ C. Its potential energy is at its highest

___ D. Its kinetic energy is at its highest

46

13. With each energy transfer, some of the ball's useable energy is lost as heat. This illustrates:

___ A. Centrifugal Force

___ B. The Theory of Heat Conductance

___ C. The Law of Entropy

___ D. Molecular Collision Theory

47

14. In general, the amount of useable energy in the universe ________.

___ A. Changes with the seasons

___ B. Is increasing

___ C. Is decreasing

___ D. Stays the same

48

15. As the ball bounces, it moves from side to side on the plate because of ______.

___ A. The air currents around the ball 49

___ B. The height of the tower

___ C. The curve of the plate

___ D. The shape of the ball

16. Who conducted the first scientific experiments on gravity? 50

___ A. Galileo Galilei

___ B. Copernicus

___ C. Leonardo Da Vinci

___ D. Isaac Newton

17. A major discovery relating to gravity is that ______.

___ A. Objects fall slower and slower as they approach the earth 51

___ B. The air currents around an object determine the direction in which the object falls

___ C. Gravity becomes stronger as one moves closer to the equator

___ D. Objects fall faster and faster as they approach the earth

18. All of the following are everyday examples of entropy except:

___ A. Pin-ball machines 52

___ B. Wind-up toys

___ C. Wrist watches

___ D. Sun-dials

NOTES

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APPENDIX A

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APPENDIX B

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