

Going APE!

at the Exploratorium
Interim Summative Evaluation Report

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Note: This report replaces all previously dated versions.

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EXECUTIVE SUMMARY

This study is the first phase of a two-part summative evaluation of a National Science Foundation-funded research/development project to investigate the development of exhibits that elicit active prolonged engagement (APE) among casual museum visitors. Naturalistic methodology was used to frame the research. Methods included unobtrusive observations, depth interviews, and tracking-and-timing. Forty-six unobtrusive observations and 35 related depth interviews were conducted on site at the Exploratorium from August 5 through 10, 2003. After all observations/interviews had been completed, additional time-at-exhibit data was collected from August 12 to 15, 2003. Following is a brief overview of the important findings.

Time at Exhibits

- The average holding time (length of engagement) was generally longer at APE exhibits than at non-APE exhibits: 132.3 seconds compared to 51.1 seconds.
- APE exhibits prompted extended engagements more frequently than non-APE exhibits.
- Although APE exhibits were more effective at prompting more extended engagements, this occurred only in a few cases.

Emotional

- At each of the exhibits under study, there was evidence that an initial driving question (e.g., Can I do this?) prompted continued intellectual and physical engagement. These driving questions tended to be different for APE and non-APE exhibits.
- At non-APE exhibits, the pleasure of discovering counterintuitive phenomena and satisfying curiosity were associated with visitor engagements.

Physical

- Most engagements at non-APE exhibits followed the consistent guided-discovery sequence of “do, observe, and read” as described in the original proposal for this project.
- At APE exhibits, visitor engagements varied in both pattern and sequence.
- Shorter physical engagements at APE exhibits were associated with (a) younger children, (b) social interruptions, and (c) unsuccessful initial attempts at one exhibit.

Intellectual

- The intellectual engagement at non-APE exhibits focused on (a) knowledge about surprising phenomena and (b) making connections to prior knowledge about similar phenomena.
- The intellectual engagement at APE exhibits varied by the nature of the driving questions presented at the exhibit.

Social

- Child-focused social engagement was observed at both non-APE and APE exhibits. In both instances, adult visitors assisted children with (a) engaging with physical elements, (b) reading labels, (c) explaining things, (d) making decisions about whether to engage, and (e) deciding when to end engagement.



- Social engagement at non-APE exhibits was generally consistent and involved pairs of visitors taking turns to use the exhibit together or individuals using the exhibit alone. Few large intact visiting groups were observed at non-APE exhibits. At non-APE exhibits, social groups often divided into pairs or individuals. Nonparticipating members of these fragmented groups often encouraged engaged group members to finish interactions and move on.
- At some of the APE exhibits, multiple large intact social groups used the exhibits at the same time. This appeared to reduce social interruptions among members of the same visiting group.
- At APE exhibits, social engagement was more diverse overall and also varied by specific exhibit.

Reasons for Engagement

- Choices about decisions not to engage were more clearly articulated by visitors at APE exhibits. This indicated that visitors recognized differences between APE and non-APE exhibits.
- Some visitors chose not to engage at APE exhibits because they judged them to be inappropriate for the younger children in their visiting group.

Reasons for Ending Engagement

- At both APE and non-APE exhibits, the end of engagement was sometimes associated with social interruptions. Some social interruptions involved members of the same visiting group prompting others to end engagement and move on. Other social interruptions involved members of other groups waiting to use the exhibit.
- At APE exhibits, social interruptions sometimes stopped an engagement before the individual was finished using the exhibit.
- Other reasons for ending engagement at APE exhibits included (a) unsuccessful outcomes and (b) younger children using the exhibit in an age-appropriate way that conflicted with exhibit use by older visitors.

Recommendations for the next phase of the summative evaluation are included in the body of the report.



INTRODUCTION

Going APE! is a National Science Foundation-funded research/development project to investigate how to develop Exploratorium exhibits that elicit active prolonged engagement (APE) among casual museum visitors. The project has two major aspects: to conduct systematic and disciplined research into the construct of active prolonged engagement in museum settings, and to develop 30 permanent APE exhibit units.

As part of this research/development process, Selinda Research Associates, Inc. (SRA) is conducting a summative evaluation to assess how and to what extent the exhibit units developed by the Exploratorium team are in fact APE exhibits.

This report is the first of two distinct phases of the summative evaluation study. This phase, which began in May 2003 and concluded in December 2003, focused on these overarching research questions:

How do visitors engage differently at a good APE exhibit compared with a good non-APE exhibit? Secondly, what are the design characteristics that seem to lead to these differences?

The findings from this first phase of the summative evaluation will inform the final design of the APE exhibit units. This evaluation study will illuminate preliminary understandings of (a) how visitors behave at APE exhibits and (b) what design characteristics facilitate and contribute to this behavior.

The second phase of the summative evaluation will begin in December 2003 and be completed by May 31, 2004. This second phase will explore the question,

In what ways and to what extent are the exhibits that the Exploratorium developed APE exhibits?

The findings from the second phase of the summative evaluation will be incorporated into the final publication being developed for this project by the Exploratorium.

The APE project is part of continuing explorations into ways to design exhibits that combine “access to phenomena with opportunities for deeper cognitive experience” (Exploratorium/*Going APE!*, p. 5). Like the *Investigate!* project at the Museum of Science in Boston and *Experiment Benches* at the Science Museum of Minnesota, the goal is to shift visitor engagement from the outcomes of the experiences to the experiences themselves. Since the 1970s, science museums have become expert in providing hands-on access to phenomena that can, through strong initial engagement created by carefully crafted labels, produce simple understandings of scientific phenomena. But providing opportunities for deeper engagement with the phenomena, thereby enabling visitors to guide and construct their own knowledge, has been more difficult. This project addresses that challenge.



The assumptions underlying the design of APE exhibits are built on constructivist learning theory.

Constructivism, as developed by Piaget and his colleagues . . . emphasizes the need for cognitive-conflict to drive learning (Gallagher & Reid, 1983; Hewson & A'Beckett Hewson, 1984). Such conflict lies in the surprise and paradox in many Exploratorium exhibits. Designing APE exhibits means providing visitors with tools to explore the conflict through experimentation, play, observation, and contemplation. (Exploratorium, *Going APE!*, p. 6)

A central assumption of this project is that both APE and non-APE exhibits can provide good visitor experiences; however, these experiences are different in nature. Good non-APE exhibits may be planned-discovery experiences that “support visitors’ expectations that exhibits will tell them what to do and how to interpret their experience. APE exhibits will not meet these expectations.” (Exploratorium, *Going APE!*, p. 8) The goal of APE exhibits is to provide visitors with opportunities to engage in their own scientific investigations, to question, wonder, and hypothesize.



METHODOLOGY AND METHODS

Methodology

This summative evaluation study used naturalistic methodology to frame the research. The goal of naturalistic inquiry is to provide a holistic understanding of the research question by collecting and analyzing data from a variety of perspectives and sources. Phenomena are studied in the natural context in which they occur. Rather than looking for an “average” experience, naturalistic inquiry aims to describe a range of visitor experiences and understandings with exhibits. This approach to understanding how visitors engage at APE exhibits is especially appropriate because museum visitors come to the experience with a variety of previous experiences, agendas, attitudes, expectations, and knowledge. They also visit in a variety of social configurations and influence each other’s experiences through social interactions, social roles, and differing agendas.

Another characteristic of naturalistic inquiry is that the overall design of the study emerges in response to themes and patterns in the data. Data collection and analysis are an iterative process. This study began with the collaborative development of a topical framework (Appendix A) to guide the research. As additional questions and themes emerged, they were explored during an iterative process of data collection and analysis.

Part of the process of developing the topical framework involved documenting the existing constructs (or attributes) used by the exhibition development team to define APE and non-APE interactions at exhibits (see Appendix B). These predefined attributes of visitor engagement at APE and non-APE exhibits were important in focusing study questions and in developing observational protocol and methods. They also provided the working definition of APE engagement at the beginning of the study.

An important aspect of the development of the topical framework was the desire to view visitor engagement from four specific perspectives: physical, intellectual, social, and emotional (Perry, 1993; *Going APE!* Exhibit Development Team, 2002a). By constantly moving among these perspectives, inquirers could more deeply understand the nature of the engagement. The framework also provided a flexible construction that allowed emerging issues and themes to be connected holistically to initial questions and assumptions.

Data Collection and Analysis

An important characteristic of naturalist inquiry is the collection of a variety of data from a variety of sources. Although often focusing on qualitative methods, naturalistic inquiry is primarily concerned with understanding the phenomena under investigation as completely as possible. In this study, this required the use of both qualitative (i.e. observation and interview) and quantitative (i.e. tracking-and-timing) data collection strategies. These three strategies are described in detail below.



In naturalistic inquiry, data collection and analysis are iterative processes. For this study we used a modified inductive constant comparison approach (Lincoln & Guba, 1985), whereby each set of data is compared with previous data sets to direct the focus of subsequent data collection.

Design of the Study

This study was a summative evaluation of a development and research project. As with most summative evaluations, the primary purpose was to investigate how and to what extent the project achieved its original goals, that is, developing and producing exhibits that elicited active prolonged engagement among visitors.

The evaluation is divided into two phases. The first phase, reported in this document, focused on identifying and defining the differences in visitor experiences between and among selected APE and non-APE exhibits. The second phase, to be conducted in spring 2004, will focus on the ultimate effectiveness of the APE exhibits.

During this initial phase of the evaluation, visitors at selected APE and non-APE exhibits were observed and then interviewed whenever possible. Observations and depth interviews were conducted on site at the Exploratorium from August 5 through 10, 2003, by Carey Tisdal of Selinda Research Associates, Inc. and five data collectors from the Exploratorium. Training in naturalistic methodology and the use of specific protocols for this study was conducted by Deborah Perry and Carey Tisdal on August 5 and 6. A total of 46 data sets were collected: 33 were at APE exhibits and 13 at non-APE exhibits. Of the total 46 data sets, 12 were collected on Tuesday, 14 on Wednesday (a free day at the Exploratorium), 7 on Thursday, 5 on Friday, 5 on Saturday, and 4 on Sunday. The free day at the Exploratorium was more crowded and appeared to have more summer program groups. (See [below](#) for a discussion of how the free day impacted the results.)

After each observation, respondent groups were approached and asked to participate in an interview. Of the total 46 visiting groups observed, 35 agreed to be interviewed.

At the conclusion of each observation/interview, data collectors wrote detailed data summaries, or debriefs. Groups of data collectors met at the end of each day for further analysis and reflection. Debriefs for individual data sets and group debriefs were included in the final data analysis. At this step, written debriefs and transcripts of selected interviews were coded to identify evidence relevant to answering the questions in the topical framework and to further explore themes and issues that emerged during the collection of the data. The initial protocols for these observations, interviews, and debriefs is presented in Appendix C. In accordance with the standards for naturalistic methodology, these protocols were adapted as necessary to individual data collection sessions to enable the data collector to follow interesting leads and to ensure adequate probing.

After all observation/interviews had been completed, Exploratorium staff collected additional time-at-exhibit data using standard tracking-and-timing procedures (Serrell, 1998). Tracking-and-timing data collection took place from August 12 to 15, 2003. Analysis of all tracking-and-timing data was completed by Selinda Research Associates using standard statistical analyses.



Selection of Exhibits

During the evaluation planning phase, it was collaboratively decided between Selinda Research Associates and the Exploratorium team that this first phase of the evaluation would focus on three APE and three non-APE exhibits. The specific exhibits were selected by consensus of the Exploratorium team members to be best examples of good exhibits in their respective categories.

The APE exhibits chosen were *Circuit Workbench*, *Downhill Race*, and *Ice Painting*. The three non-APE exhibits were *Bubble Suspension*, *Touch the Spring*, and *Water Standing on Air*. Criteria for selection included both theoretical and practical issues.

The non-APE exhibits were all chosen to be excellent examples of the classic Exploratorium exhibit: surprising, exciting, interesting, but with few options for in-depth exploration of the phenomena. The exhibits also have interesting explanations of the phenomena, but it would be difficult for visitors to figure out the phenomena themselves, without reading the label. (*Going APE!* Exhibit Development Team, 2003a)

Exhibits were placed in the sound abatement area near the entrance to the Exploratorium, making them some of the first exhibits that visitors saw. APE and non-APE exhibits were arranged among other exhibits to allow visitors to assess and select engagements as part of their normal visit agenda and to allow for unobtrusive observation.

For the tracking-and-timing portion of the study, one additional APE exhibit and three additional non-APE exhibits were added for observation. This allowed respondents moved freely among all the exhibits in the immediate area, and alleviated the problem of respondents repeatedly moving in and out of the tracking-and-timing study area.

Selection of Respondents

Visitors were selected for observation/interview on the basis of purposive sampling (Miles & Huberman, 1984). In purposive sampling, the goal is to select respondents based on specific characteristics that will provide additional evidence to answer the questions of the study. These characteristics may be related to demographic characteristics such age, gender, and social group. In this study, however, it was also important to compare and contrast engagement at APE and non-APE exhibits and various types of APE exhibits themselves.

As the study progressed, researchers identified interesting differences in the nature of the engagement at the three APE exhibits that required further exploration. For this reason, during the later days of data collection we focused on visitors to the APE exhibits and chose to observe fewer engagements at non-APE exhibits, where engagement patterns were already relatively clear.

Since social interaction was one focus of the study, case data was mixed. That is, some observation/interviews focused on individuals whether alone or in a group, and some focused on engagement of the entire group at the exhibit. Data collectors described in their debriefings the makeup of the social group and why a group or individual was selected for observation. See Appendix G for descriptions of observation/interview respondent social groups.



Exploratorium staff collected the tracking-and-timing data using standard protocol (Serrell, 1998). Respondents were selected randomly – every third individual to cross an imaginary line on the floor – to allow us to calculate statistics and compare times and engagement at exhibits. After noting the respondent’s gender and group information, his or her time at individual exhibits and the path taken through a selected number of exhibits was recorded. A total of 89 respondents were tracked. See Appendix D for a more detailed breakdown of tracking-and-timing respondents.

Unobtrusive Observations

Unobtrusive observation is a technique that allows visitors’ behaviors and conversations to be documented with as little interference as possible from the evaluator (Lincoln & Guba, 1985). In some instances data collectors are hidden from the respondents behind a two-way mirror, or they use a video camera. For logistical reasons and because it was important to overhear as much of the engagements as possible, in this study data collectors chose places on the exhibit floor where they would not be noticed by visitors. Signs were placed in the area to inform visitors that observations were taking place so they could avoid the area if they did not wish to participate.

Depth Interviews

Depth interviews enable researchers to explore in more detail observed visitor engagement. Unlike highly structured interviews that restrict visitor response, depth interviews are more like a conversation about the experience between the data collector and the respondent (Lincoln & Guba, 1985). This allows respondents to share their own perspectives about the nature and the meaning of the interaction. In this study, each depth interview was guided by a protocol containing several common questions. These questions served to initiate the conversation with visitors and also ensured that a few common themes were always explored. As appropriate, data collectors also followed up on points of interest in the conversation and added questions that emerged from previous data sets as well as the preceding observation. During this study, emergent questions included how visitors chose to begin and end engagements and if there were differences in this process between non-APE and APE exhibits. Data collectors tape-recorded interviews with permission of the respondents. Immediately after each interview, the data collector wrote a narrative summary of the observation/interview as part of the debriefing process.

Tracking-and-timing

Tracking-and-timing is commonly used to assess the amount of time a visitor spends at particular exhibit units and to record his or her path through a gallery. In this study we were interested in whether -- on average -- visitors spent longer periods of time at APE exhibits compared with non-APE exhibits.

A stop at an exhibit was defined as when a respondent planted his or her feet or touched the exhibit for 2 seconds or longer. The times a visitor started using the exhibit and left the exhibit were recorded. If a respondent stopped at an exhibit more than once, the separate times were totaled. A sample of the tracking-and-timing instrument is included in Appendix H.



FINDINGS AND DISCUSSION

Overview of Sections

To answer our questions about visitor engagement at APE and non-APE exhibits, we have divided our discussion into three major areas: time of engagement, patterns of engagement at non-APE exhibits, and patterns of engagement at APE exhibits. Time data provides an overarching perspective about the differences between the two types of exhibits. Then, we use characterizations of engagement at non-APE exhibits as points of comparison from which to understand visitor engagement at APE exhibits. In other words, descriptions of visitor engagement at non-APE provide a baseline from which to view visitor engagement APE exhibits. For each exhibit, we describe the range of physical, intellectual, social, and emotional engagements, and how visitors made choices about engagements. Overall comparisons are described in the section entitled Conclusions.

To characterize and compare engagement at exhibits, we analyzed observations and interviews to find patterns related to five perspectives: (1) time of engagement, (2) physical engagement, (3) intellectual engagement, (4) social engagement, and (5) emotional engagement. In addition, a sixth perspective emerged from the data: choices about engagement. *Physical engagement* is defined as the different ways in which visitors physically interact with an exhibit. Physical engagement includes the amount of time they spend, the labels they read, where they sit or stand, and what buttons they push. It also includes the sequence of activities they participate in. By analyzing physical engagement, it helped us understand whether an interaction was primarily guided by the exhibit design or if visitors engaged in self-directed exploration.

Intellectual engagement is defined as the various ways in which visitors engaged with their minds. Intellectual engagement is often referred to as “minds-on” to contrast it with hands-on. It includes the connections visitors make to existing knowledge during their interaction, the conceptual understandings, and the questions they have. An area of intellectual engagement that emerged as important during this study was visitors’ level of awareness of the type of learning experiences they encountered at APE and non-APE exhibits and whether this affected their decision to use the exhibit, particularly with younger children.

Social engagement is defined as the many ways that visitors influence each other’s experiences at exhibits. It includes conversations among visitors that might guide what an individual does or understands during the interaction. Social engagement also includes directions, observation, guidance, assistance, cooperation, and competition among visitors using an exhibit at the same time, as well as deliberate teaching/learning behaviors, such as a parent asking a child a question to get the youngster engaged in the exhibit, or one person explaining something to another visitor. Another factor is the impact of other members of a social on the respondent, whether they are present or in another part of the museum at the time of the engagement.

Emotional engagement involves both the nature and intensity of the affect exhibited by visitors during the engagement and immediately after. The nature of the emotional engagement may be positive (fun, awe, pleasure, enjoyment, caring) or negative (embarrassment, confusion, disdain,



humiliation). Affect seems to indicate preference, that is, it tells us which things individuals value more than others (Izard, Kagan, & Zjonic, 1984). The intensity of the emotion tells us about the level of this preference. During an interaction at an exhibit, the subject of this emotion may be an element of the exhibit itself, other visitors, or the environment of the interaction, e.g., temperature, level of crowding, noise level.

Choices about engagement involve how and why visitors chose to engage at this particular exhibit and how and why they chose to end the engagement. This feature of engagement emerged during observations as data collectors tried to understand the wide range of engagement times at exhibits, especially among visitors at APE exhibits.

Time of Engagement

One of the main goals of the study was to understand the differences between how visitors spent time at the APE exhibits and at the non-APE exhibits. Two types of timing data were collected to address this and other time-related questions: (1) tracking-and-timing data and (2) total time at exhibit for purposive sampled observations. We looked at each type of data individually and then examined the relationships between them.

Observational Time Data

For each observation, data collectors were asked to report the beginning time, the ending time, and the total time. Observations were coded by length-of-engagement (holding time). The categories reflect natural breaks in the observational time data and are generally consistent with our experience with holding time at exhibits in other studies. This allowed us to compare what was occurring between shorter and longer engagements in general, and between shorter and longer APE engagements specifically. Individual observations (data sets) coded by time categories can be examined in Appendix E.

Category	Definition
5=Very Extended	>8 minutes to 23 minutes
4=Extended	>5 to 8 minutes
3=Substantial	>3 to 5 minutes
2=Brief	>1 to 3 minutes
1=Very Brief	1 minute and under

While most of the longer engagements (substantial, extended, and extended) we observed were at APE exhibits, we also saw three longer engagements at non-APE exhibits: one at *Touch the Spring* and two at *Bubble Suspension*. These engagements were exceptions to the patterns we identified, so we looked closely at the observations to find out why. In one case, an individual became involved observing a phenomenon; her behavior was much like that of respondents we observed at *Ice Painting*. This probably reflects the strong attraction of fascinating phenomena that we found at other exhibits, but alone it is simply an anomaly. In other cases, visitors used exhibits as the focus for primarily social interactions. These cases do not cast much light on the difference between APE and non-APE engagement, and as such, are simply examples of the wide range of visitor behaviors that occur in museums.



Tracking-and-timing Data

Information from the tracking-and-timing study provided a picture of central tendencies that are helpful in comparing APE and non-APE exhibits. (A detailed presentation of the analysis of tracking-and-timing appears in Appendix D.) Figure 1 shows the descriptive statistics for individual exhibit units in minutes.

Figure 1: Tracking-and-timing Data (in minutes)

Exhibit Name	Type	N	Mean	Median	SD	Range	Min	Max
<i>Downhill Race</i>	APE	51	1.7	1.3	1.6	7.5	0.1	7.5
<i>Floating Objects</i>	APE	49	2.0	1.3	1.7	6.5	0.2	6.7
<i>Ice Painting</i>	APE	26	1.4	1.0	1.2	4.9	0.1	4.9
<i>Bubble Suspension</i>	Non-APE	36	0.9	0.8	0.7	3.7	0.1	3.7
<i>Circling Waves</i>	Non-APE	29	0.6	0.4	0.6	2.6	0.1	2.7
<i>Liquid Litmus</i>	Non-APE	26	1.3	1.0	0.9	3.5	0.1	3.6
<i>Rift Zone</i>	Non-APE	60	0.8	0.6	0.8	4.6	0.0	4.6
<i>Touch the Spring</i>	Non-APE	33	1.4	1.2	0.8	2.8	0.1	2.9
<i>Water Standing on Air</i>	Non-APE	34	0.7	0.7	0.6	2.5	0.1	2.6

Each of these individual distributions was non-normal, reflecting the highly skewed numbers typical of time data at most museum exhibits. That is, the holding times at each exhibit contain a majority of cases with relatively shorter times and a few extremely longer times. The range of holding times (engagement), however, was generally larger for the APE exhibits than for the non-APE exhibits. This pattern was consistent with timing data collected during the observational phase of study.

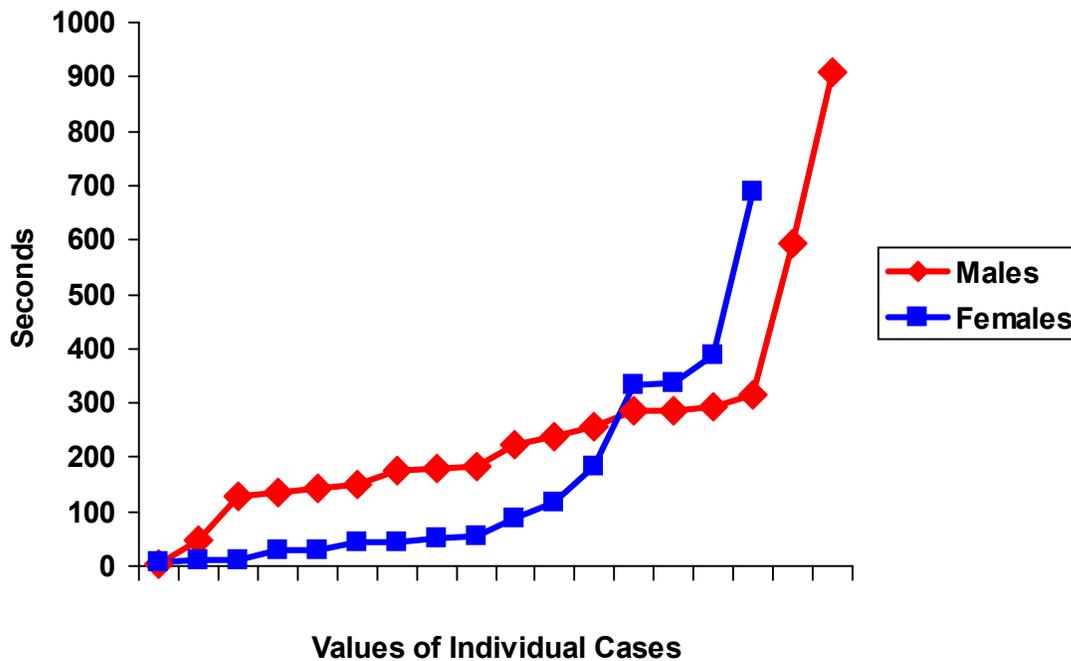
To compare engagement at APE and non-APE exhibits, average holding times for each individual were calculated by totaling his or her time at APE exhibits and then dividing by the number of APE exhibits at which that individual respondent stopped. The same procedure was followed to calculate an average engagement score for each individual at non-APE exhibits. These can be considered an APE score and a non-APE score for each individual. The mean APE score was 132.3 seconds (SD=113.7) with a median of 108.0 seconds. The mean non-APE score was 51.1 seconds (SD=32.2) with a median of 49.3 seconds. A significance test was calculated to compare average times at APE and non-APE exhibits. Since these are non-normal distributions, a nonparametric test was used to compare the groups. We calculated a Wilcoxon Signed Ranks Test for two related samples. The groups were significantly different at the $p < .001$ level. This indicates that respondents tended to spend significantly longer times at APE exhibits in general than at non-APE exhibits. We also calculated group comparisons for gender, age, and group size



using a nonparametric test, the Mann-Whitney U for independent samples. None of these differences were significant.

We also compared individual exhibit holding times by gender, age, and group size. We used a nonparametric test for this non-normal data, the Kruskal-Wallis Test for independent samples. We found only one significant difference: Male and female visitors at *Circuit Workbench* had significantly different times of engagement $p < .05$. The male mean was 4.2 minutes (SD=3.4), and the female mean was 2.4 (SD=3.2). Figure 2 shows the distribution of male and female holding times at *Circuit Workbench*. This distribution shows that the difference in these means can be attributed to numerous very short engagements among female respondents. Several were under 100 seconds, compared to only one such time among the males. We will discuss some possible reasons for this difference in the *Circuit Workbench* section of this report.

Figure 2: Value of Individual Cases at Circuit Workbench



To analyze relative attractiveness of exhibits, we ran cross tabulations with Chi-square tests on the number of stops at each exhibit unit by gender and calculated correlations between (1) number of stops at each exhibit and age groups and (2) number of stops and group size. There were no significant differences by gender. We found one significant different by age. Stops at *Liquid Litmus* were correlated with age .30, $p < .001$. In addition, stops at *Downhill Race* were positively correlated with group size. The correlation was .30, $p < .05$. This means that larger groups were more likely to stop at *Downhill Race*.

Relationships between Observational and Tracking Data

Since holding time, or length of engagement, was a critical element in this study, it was important to understand the relationship between the observational time data, which provides a context for understanding prolonged engagement, and tracking-and-timing measures, which provide a representative picture of how often these types of engagement occur.

Figures 3 and 4 show the relative frequency of the categories of engagement that emerged from the observational study applied to tracking-and-timing data. The type of exhibit is indicated in each graph by the letter preceding the exhibit name. "A" means this was an APE exhibits, and "N" indicates this was a non-APE exhibits. In Figure 3, we can see considerably fewer very brief and brief (less than 3 minutes) engagements at APE exhibits. Figure 4 shows the inverse by focusing on the longer engagements.

Figure 3: Percentage of Brief and Very Brief Engagements (< 3 minutes) at All Exhibits

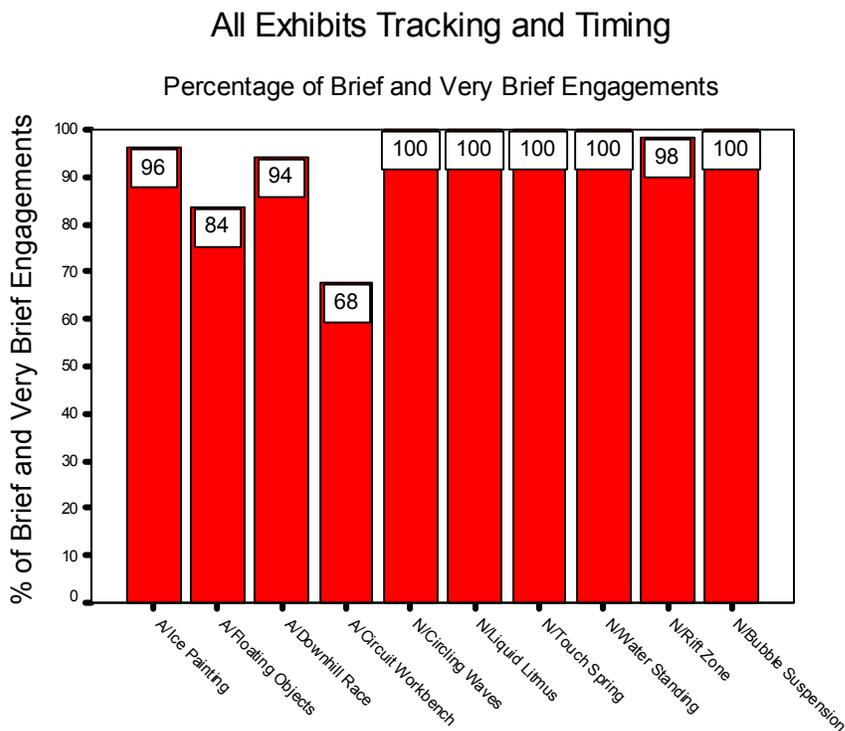
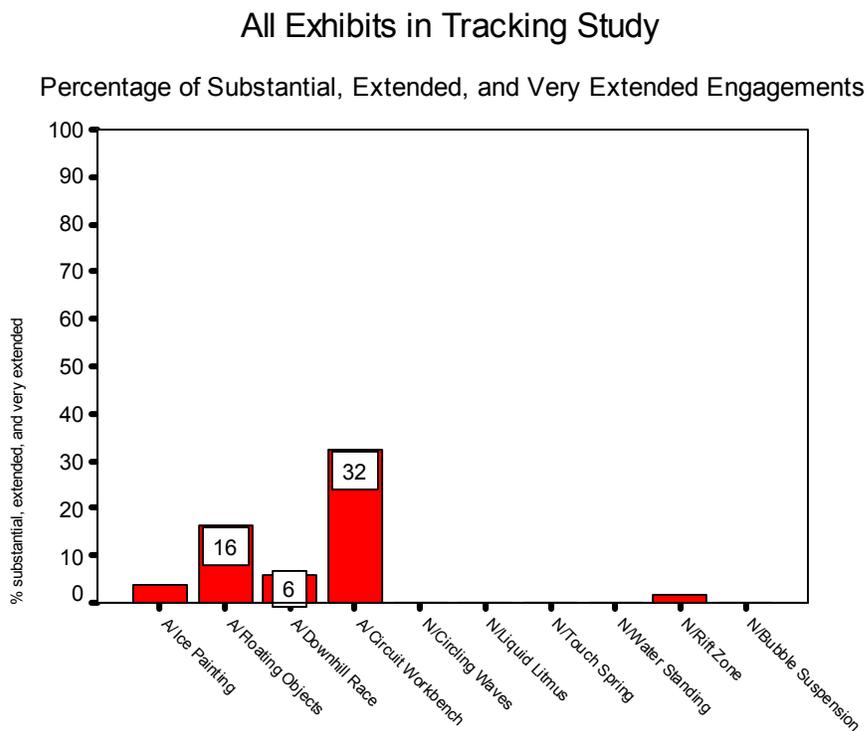


Figure 4: Percentage of Substantial, Extended, and Very Extended Engagements (>3 minutes) at All Exhibits



These two graphs help clarify the frequency of extended engagements in the tracking study. There were more substantial, extended, and very extended engagements (3 to 23 minutes) in the tracking-and-timing study at APE than at non-APE exhibits. But the overall number of longer engagements -- those that can be generalized to the overall visiting population -- was not great.

These relationships among time data are important to understanding respondents' use of time at APE and non-APE exhibits. Statistical analysis showed very few differences in APE and non-APE exhibit use by gender, age, or group size. Also of note, the crowded situation on the free day did provide data on the impact of crowding, but crowding did not prevent all longer, more intense engagements. On that day, 9 of the engagements we observed were under two minutes. However, 5 of the engagements on the crowded free day were longer, ranging from 3 to 13 minutes. This makes it important to understand the differences in the *nature* of engagement between shorter and longer holding times.

Engagement at Non-APE Exhibits

The three non-APE exhibits included *Bubble Suspension*, *Touch the Spring*, and *Water Standing on Air*. In each section below, we present the exhibit description provided by the team, followed by a characterization of engagement at the exhibit based on observational and interview data.

Bubble Suspension

We conducted five observations and four interviews with respondents at *Bubble Suspension*. Times of the engagements ranged from 1 minute to 10 minutes, with most around 2 minutes. We



selected a range of social groups to observe including 1 little girl alone, 1 woman alone, a parent/child dyad, a group of teens, and a family group with grandparents.

Exhibit Description

At Bubble Suspension, visitors blow bubbles into a big, clear acrylic cylinder and watch as their bubbles hover and swell on top of an invisible blanket of carbon dioxide gas, produced from a chunk of dry ice at the bottom of the exhibit. Because straight carbon dioxide gas is heavier than air, the bubbles sit on top of the gas instead of falling to the floor as they normally do. Because bubbles' membranes are semi permeable, carbon dioxide slowly seeps into them, which is why they get bigger and begin to grow heavier. Sometimes the membrane gets stretched so thin the bubble seems to vanish; other times the bubble shell gets frozen from finally coming into contact with the dry ice. (*Going APE!* Exhibit Development Team, 2003a)

Physical Engagement

We observed a fairly consistent range and sequence of interactions at *Bubble Suspension* among all types of visitors. In all observations, after approaching the exhibit, people blew bubbles, then observed the bubbles settling and floating. Almost all read the label. In two groups, someone read the label aloud. When the area was crowded, respondents watched others using the exhibit before using it themselves. We saw one longer engagement. In this case, a woman using the exhibit by herself appeared to get caught up in the phenomenon and spent several minutes watching the bubbles freeze at the bottom of the tube as they settled on the dry ice. In most cases, however, respondents left shortly after reading the label.

Intellectual Engagement

Based on interview data, almost all the respondents, except very young children, got the basic idea that carbon dioxide from the dry ice made the bubbles float. Children under 6 seemed happy just to have an opportunity to blow bubbles. Only the woman with the longer engagement had questions. She was surprised that dry ice would freeze the bubbles and was curious about whether the temperature of the bubble liquid mattered in how quickly, or if, the bubbles froze. She explained,

Well, I mean, the dry ice. I mean, I never had any idea that – I mean, when you freeze them [the bubbles]. I mean, I know you use dry ice in keeping, you know, things frozen. Seems like an oxymoron – dry heat, you know.

Her questions appeared to move beyond the explanation, indicating curiosity about the nature of dry ice and the temperature variable. But for most respondents, the label information seemed to satisfy their initial curiosity, and after reading it, they quickly moved on.

Social Engagement

One common social behavior we saw was visitors watching others while waiting their turn. Since only one person at a time can use the bubble wand, taking turns was necessary for people to use the exhibit as a group. Due to the popularity of the exhibit, groups had to wait for another group to finish before they could begin. In some instances, leaving appeared to be cued by another



group of visitors walking up to the exhibit. As one mother said to the children in her group, “Okay, let’s go and let other people use it.”

We found here, and at other exhibits, that social groups often divided into smaller units to use individual exhibits. Both of the individuals we observed using this exhibit “alone,” we learned later, were part of larger groups visiting the Exploratorium. A grandfather-granddaughter pair we observed using *Bubble Suspension* were part of a larger family group that the data collector noted was waiting patiently nearby. Many of the observations at *Bubble Suspension* were among dyads, or pairs of visitors.

We saw adults and children approaching the exhibit first and leading others to interact with it. In one case, a little girl approached, followed by her mother, who helped her use the bubble wand. The child exclaimed “Yeah!” when she succeeded. In another, an adult female, who we assumed to be the mom, approached the exhibit, called over her husband and sons to use it, and even called them back to read the label. In all these cases, we observed child-centered behavior among the adults. That is, whether helping with the use of the exhibit components or reading the label, the adult’s primary focus was on the child’s use and understanding of the exhibit rather than on his or her own.

Conversations were difficult to hear over the general noise in the area, and we were not able to collect specific conversational data. We did see visitors pointing, talking, and reading the label aloud to others in their groups.

Emotional Engagement

In general, the emotional response to this exhibit was mild and pleasant. As described in the proposal, this guided-discovery exhibit initially provoked curiosity by presenting an unusual phenomenon. One teenaged girl explained,

I just – when I saw it, I thought it was kind of something out of the ordinary to see bubbles floating and that – and so, I – you know, I thought, ooh, what’s doing that?

Most of the adults and teens we interviewed described this experience as “fun” or “cool,” but their curiosity seemed to be satisfied by the label and appeared to end quickly.

Choices about Engagement

Both intellectual and social factors appeared to be important in deciding to start and end engagement at this exhibit. In two specific cases, a lone woman and a teen group, the respondents appeared to be attracted to use the exhibit by the phenomenon. The teens left after briefly trying the interactive and reading the label. Their decision to leave appeared to be because their curiosity was quickly satisfied. The adult woman watched the phenomenon for 10 minutes before relinquishing her spot when other visitors crowded around to use the exhibit. Her curiosity about the materials in the exhibit remained high, even after the engagement ended.

But several of the engagements we observed involved young children, and in interviews (as well as in declined interviews) we found the attention of these groups focused on the interests, attention span, and behavior of these younger children. In one group with a 4-year-old boy, we watched the mother take the lead, calling the father and the child over to the exhibit. After a brief



engagement, the little boy ran to another exhibit, followed quickly by the father. The woman stayed behind and finished reading the label before joining her family. In another engagement, a 6-year-old girl and her grandfather used the exhibit while the rest of the group waited nearby. The grandfather explained that they had chosen the exhibit because “Ann likes to blow bubbles.” The rest of the group (which included adults and older siblings) did not use the exhibit, but waited for the little girl and her grandfather. In an engagement involving a girl about 6, an 8-year-old brother waited nearby and did not engage with the exhibit. The mother noticed other people waiting and said, “Okay, let’s go and let other people use it.” This mother appeared able both to manage the interests of her two children and use exhibits in the context of shared public space.

Exhibit Design Characteristics

- *Bubble Suspension*’s conceptual design clearly fit that of a guided-discovery exhibit as described in the *Going APE!* proposal. The adult visitors and teens we observed appeared to watch the “surprising phenomenon” and then satisfy their curiosity by reading the label. In only one case did the exhibit seem to prompt more intense curiosity about the phenomenon.
- Only one person at a time could interact directly with the exhibit components. This influenced group behaviors such as taking turns and observing other visitors use the interactive element. The number of people that can participate at one time may also be a factor in groups splitting into smaller configurations to use exhibits.
- The interactive appears to be appropriate for younger children, but some older respondents chose not to use the exhibit.

Touch the Spring

We conducted four observations at *Touch the Spring*, and in three cases, people agreed to be interviewed. We watched 2 individuals use the exhibit alone, 1 parent-child pair, and a large group of teenagers visiting from Spain. Most interactions at the exhibit lasted about 1 minute. The group of Spanish teens spent about 13 minutes at the exhibit.

Exhibit Description

Touch the Spring. At this exhibit, visitors reach into a box to touch a perfectly normal-looking spring, but their hand goes right through it. The spring is actually a “real image” of a spring, produced by a very smooth, large curved mirror that is inside the box. (There’s a real spring inside the box as well.) When visitors shine an attached flashlight onto the image of the spring, the reflections and shadows make it look even more real. That’s because the flashlight’s light goes into the box, reflects off the mirror, hits the real spring inside, and bounces back out to the image. The real spring inside the box gets lit up and shadows get produced in such a way that the image of the spring looks like its being lit up and shadowed. . . . (*Going APE!* Exhibit Development Team, 2003b)

Physical Engagement

The range and sequence of physical engagement at this exhibit was limited and somewhat consistent across visitors. All the respondents began by walking up to the exhibit and reaching inside the hole toward the image of the spring. In two cases, people used the flashlight. Two individuals reached up under the exhibit to try to grab the actual spring with their hands, a



behavior not suggested in the label or implicit in the design of the exhibit. This appeared to be self-generated behavior. In two instances, visitors turned to the label and read it to understand what was going on. But two other groups never looked at the label or the diagram. In three cases, the two people alone and the parent-child dyad, these were brief engagements. Visitors appeared to leave when they had figured out what was going on.

The exception to this pattern was a large group of Spanish teens. While the initial engagement began in a way similar to other observations, all six members of the group crowded around and reached in over each other's shoulders. Conversation appeared to include laughing and calling others over to share the joke. One young man used the flashlight to shine it into a young woman's face in a playful manner. It appeared that they never read the label or noticed the diagram on the side of the exhibit. The limited English among the teens may have made them less likely to look for written text explanations, but their intent seemed to be primarily social.

Intellectual Engagement

Interaction at this exhibit appeared to elicit and confirm prior knowledge for some respondents. Both adult males using the exhibit alone referred to prior experience with these concepts. One was a mechanical engineer, and the other developed holographs as a hobby. A young boy and his mother using the exhibit together appeared to understand the concept for the first time. The boy, about 10, read the label and could explain the function of the mirror inside in producing the image and reflecting the light. The Spanish teens appeared to never quite understand how the illusion worked and continued to be curious about the phenomenon even after using the exhibit.

Social Engagement

We observed a range of social interaction at *Touch the Spring*. Two individuals used the exhibit alone and there was no interaction with other visitors. The young boy and his mother used the exhibit together, and the mother pointed out the labels for the boy to read. Similar to adult-child engagements at *Bubble Suspension*, this was another instance of child-focused adult behavior. Finally, the Spanish teens' engagement was primarily social, and their limited knowledge of English may have made the payoff of this guided-discovery exhibit inaccessible to them.

Emotional Engagement

Touch the Spring elicited amusement and sometimes laughter among the people we observed. In interviews, the humor of the exhibit was noted. One mom said she read the label first, and this led her to expect a trick or illusion. A mechanical engineer said he thought about "Wiley Coyote and the Roadrunner" when reaching up under the exhibit. For the people who reached under the exhibit to try to locate the real spring, this non-exhibit-directed activity was mischievous fun because it sidestepped the rules.

Choices about Engagement

Touch the Spring was located on a busy visitor pathway during the observations, and most visitors we interviewed appeared to have accepted the invitation to *Touch the Spring*. Among cases with shorter engagements, respondents left when they understood what was going on, that is, they had satisfied their curiosity. Because the exhibit was popular, the decision to leave also appeared to be influenced by another group waiting to use the exhibit. The group of Spanish teens seemed to use the exhibit as an opportunity to joke with and tease each other. Their engagement appeared to end when all members of their group had seen the "joke" and others had



watched them be “fooled.” Satisfying their curiosity about the phenomenon did not seem to be a high priority.

Exhibit Design Characteristics

- While, in general, the visitor behavior at this exhibit clearly fit the guided-discovery design concept described in the proposal, we did observe instances of self-generated exploration, that is, reaching under the exhibit to find the real spring. Most engagements, however, were brief, and when initial curiosity was satisfied, respondents moved on to another exhibit.
- Like *Bubble Suspension*, the exhibit appears to be designed for only one person to directly interact with the exhibit elements at a time. In our observations, we did see a large group crowding in to use the exhibit together, but this appeared to be an exception involving a large non-English-speaking group of teens.
- The English-only labels appeared to limit accessibility to this guided-experience exhibit, in which observation alone will not lead to an understanding of the phenomenon.
- The humor involved in the exhibit tone appeared to elicit social engagement among some respondents.

Water Standing on Air

We watched four interactions at *Water Standing on Air* and conducted three interviews with respondents. We observed a man and a girl, 9, who we later found were part of a larger family group; a man with 4 children under 5 (one in a stroller), whose wife was waiting nearby; and 2 male/female couples in their 20s. All engagements were very brief, ranging from 1 to 2 minutes.

Exhibit Description

Water Standing on Air. A closed, cylindrical glass tube contains some water. In the center of the tube is a screen or grate that the water passes through whenever the cylinder is turned upside down. However, when the cylinder is turned over quickly and smoothly, water does not pour through the grate; instead, it sits on top of the grate. In effect, water “stands on air.” What’s happening is that when the water covers all the holes in the grate, air cannot pass from the bottom half of the tube to the top half of the tube – air cannot “equalize” in the tube. (Water’s surface tension keeps the air from coming through.) The water presses down slightly through the holes in the grate. This causes a compression of the air in the bottom half of the tube and increases the air’s pressure down there. At the same time, the water pressing down means that the air above the water is rarefied, so its pressure decreases. The difference in air pressure is what holds up the water. (*Going APE!* Exhibit Development Team, 2003b)

Physical Engagement

In all the observations, the range and sequence of physical behavior was fairly consistent. In general, respondents walked up to the exhibit and flipped the tube very quickly, and the water went through the mesh, that is, it didn’t “stand on air.” Respondents in three groups glanced at the label, attempted flipping the tube several times, and finally achieved a successful outcome. One young couple never got the water to stand on the mesh. Respondents then glanced back at the label and left. The only variation we saw appeared to be whether respondents looked at the



label before or after the first unsuccessful attempt and one instance in which the final outcome was never achieved.

Intellectual Engagement

Most of the intellectual energy in these engagements appeared to be focused on making the exhibit work and achieving a “successful” outcome by making the water stand on the mesh. When asked, respondents said that they were not surprised that the water would stand because that is what the label said it would do. In interviews, the primary questions people said they had when using the exhibit was, “How does it work?”

Social Engagement

In family groups, we observed one case where the adult male approached first (father with four children under 5) and another where the female child, age 9, approached first. This behavior appeared to be influenced by both the size of the group and the age of the children. In the case of the father and mother with very young children, he appeared to be taking the role of the “scout,” finding exhibit experiences, using them himself and then demonstrating them to the older child, age 4 or 5. The mom stood nearby and appeared to focus her attention on managing the other children. The 9-year-old girl selected the exhibit, calling out, “Watch this, Dad!” This is another instance of child-centered behavior among parents with children.

We also watched two young couples use the exhibit. In one case, the female approached first, and in the other, the male initiated the interaction. In both cases, the other respondent watched and when the first person moved aside, the second flipped the tube. This was another example of turn-taking behavior.

All respondents talked to each other as they used the exhibit, and these conversations appeared to be about making the exhibit “work.”

Emotional Engagement

The 9-year-old girl we interviewed enjoyed using the exhibit, saying, “It’s great because the water just stood there.” She was animated and seemed to enjoy the experience of using the exhibit and showing it to her dad. Both couples expressed frustration about making the exhibit work and made suggestions about how the exhibit could be improved. The family group with several young children declined to be interviewed; the father said he needed to “help with the kid” and didn’t want to leave his group for the time an interview would take.

Exhibit Design Characteristics

Unlike the two other non-APE exhibits, respondent behavior at this exhibit appeared to be focused on making the exhibit work rather than on satisfying curiosity. Respondents appeared to accept that the water would stand on air from label information and showed little curiosity about the phenomenon.

Like *Bubble Suspension* and *Touch the Spring*, this exhibit allows only one individual at a time to interact with the physical elements of the exhibit. Respondents using the exhibit in pairs appeared to take turns. In two instances, we observed “pairs” from larger groups splitting off to use the exhibit while the larger group waited nearby. This indicates that respondents assessed this exhibit as a one- or two-person experience.



Unlike *Bubble Suspension* and *Touch the Spring*, this exhibit offers a challenge to “make it work.” Implicit in this is the possibility of several trials to make it work, and the possibility of an unsuccessful outcome.

Choices about Engagement

Two of the cases we observed at this exhibit had viewed the exhibit earlier and returned to use it when it was free. In groups with children, the children approached first, and then an adult -- in one case a father and in the other a mother -- followed the child to the exhibit and assisted in getting the water to stand on the mesh. Since respondents we talked with were clearly focused on “getting it to work,” leaving the exhibit was almost always connected directly to the outcome. In two cases, the respondents were able to make the water stand and quickly left. In two others, people were not able to get the water to stand, appeared mildly frustrated, and left.

Engagement at APE Exhibits

Circuit Workbench

We conducted 13 observations at *Circuit Workbench* and 11 interviews. The lengths of engagement ranged from 1.5 minutes to 23 minutes. Two were in the very extended category, 5 were in the extended category, 3 were in the substantial category, and 2 were in the brief category. (The time of one engagement was not recorded.) We saw 3 individuals using the exhibit alone, a young couple, 6 adult-child/teen dyads, and three groups of 3 or more.

Exhibit Description

Circuit Workbench. At this Construction APE exhibit, visitors are given real-world missions, such as “make a bicycle light generator,” and use banana-plug wires to build circuits that underlie those real world devices. The exhibit has six stations, which vary in difficulty level. Visitors can try the challenges (for which there is a solution given under a flip-up), or they can construct any other circuits they wish to make. At each station, there are extra components that aren’t needed in the mission so that visitors can make many different circuits. Components include batteries, generators, incandescent lights, LED lights, motors, switches, and variable resistors. Visitors may also use the wires to connect components across stations. (*Going APE!* Exhibit Development Team, 2003b)

Physical Engagement

The sequence of interactions was more varied at *Circuit Workbench* than at any of the non-APE exhibits. In addition, the exhibit offered a greater range of physical interactions. Regardless of their length of stay, respondents all went through repeated trials of moving wires and plugs to build circuits. In almost all the observations, respondents did not lift the flaps and look at labels until after they had attempted a task. In many of the shorter engagements, respondents went through a couple of unsuccessful trials, looked at the label and then left without going back to the task. Respondents in substantial and longer engagements were also seen lifting labels, but only after attempting the task. Observations are not detailed enough to tell if any lifted the labels at the first station they used or only at the more difficult ones. Interviews indicated that lifting the flap or not lifting the flap had a major emotional component. This is discussed later in this section.



Intellectual Engagement

From the interviews we conducted, it appeared that prior knowledge played an important role for respondents in both selecting and using this exhibit. In interviews, we heard from parents that they had chosen this exhibit because it allowed them to teach something they were knowledgeable about to their children. One father said,

I'm in the robot business. We sell, market, find applications for robots in industry in science. . . . I'm an electrician, that's a past incarnation, and I saw it as something that I could explain well to my son.

Another case involved a mother with her daughter. The mother at first said that she chose the exhibit for her daughter: "After all, I come here for her." This university-level science educator noted that she saw this as a good teaching opportunity because the circuits were hooked up in ways that were easy to explain. She told us that she regularly taught this subject to her college-age students. Later in the interview, this mom looked sheepishly at the data collector and admitted that she had chosen the exhibit because of her own interest. Her embarrassment indicated that she perceived that the engagement should have been centered on her child rather than on herself. This is a consistent attitude with many parents at non-APE exhibits.

Other respondents also told us they chose to participate at *Circuit Workbench* because of prior experience. One female teen talked about her science fair project on batteries, and a couple of male teens talked about electronics as a hobby. Three of the adult males we talked with said they were engineers. Several, but not all, of the respondents with prior knowledge had longer engagements than respondents who did not mention this factor in their interviews. Individuals with prior knowledge rarely indicated that they learned anything new; rather, they explained, they found the exhibit to be an intellectual challenge where they could test their own knowledge.

Based on interviews, most visitors with substantial and longer engagements had few questions after the experience. As one respondent explained, her questions were more about specific components and how to hook them up in the circuit than about why it worked. One data collector described this as application of theoretical knowledge rather than learning new knowledge.

Another respondent, who had a very satisfying exhibit experience with his son, said the engagement made him wonder about the Exploratorium staff,

IT WAS GREAT! I was looking at it and wondering about what the people that built it were doing, they must be interesting people. I'm always wondering about the fabrication of things.

Respondents with shorter engagements told us that their primary questions were about why they could not "make it work." One young woman said that the question she asked herself while using the exhibit was, "Am I doing this right?" Still other respondents who had unsuccessful outcomes appeared to attribute difficulties to the exhibit. Two adult males commented that some aspect of the exhibit was broken.



Social Engagement

This exhibit appeared to be used by a variety of social groups: individuals alone, couples, adult-child dyads, and several groups of three or more. Individuals alone appeared very involved in their own experience and did not interact with other visitors. Among the adult-child/teen dyads, we observed both child-centered, didactic roles played by adults and cooperative behaviors. Cooperative behaviors involved two people using the same station together and either an adult or a child looking up from his or her own task to help someone else find a solution. Most of the conversations we overheard were task-oriented such as “Try that,” or “Put that one in here.” Other conversations involved group management as people called each other over to use the exhibit or left the exhibit to join other members of larger visiting groups.

Emotional Engagement

Of all the exhibits we observed, *Circuit Workbench* appeared to evoke some of the strongest emotional responses. From respondents who had longer and more successful encounters, we frequently hear the words “fun” and “challenging.” As one young man who used the exhibit with his father explained, they were “having fun . . . [with the kind of challenge that] makes you want to get more into it.”

The term “challenge” was heard again and again in relation to this exhibit, especially as people explained their use of the labels. A young man who used all six stations during a 23-minute engagement stated proudly that he had not had to look at the labels “even once.” A science education professor said she “only” had to look once, when she had a question about variable resistors. Several respondents appeared proud that they had not had to use the labels to meet the challenges provided by the exhibit.

Others seemed frustrated, and a few were defensive. One young man who used the exhibit with his mom explained, “We couldn’t figure it out. [We] had to switch it around until we got it to work.”

Unsuccessful outcomes also appeared to evoke injured pride. “I was surprised I made a mistake,” said one engineer. He attributed this to the exhibit: “It [the exhibit] wasn’t so clear how the current flows there.” Another engineer, after briefly trying one station and having an unsuccessful outcome, described the exhibit as “banal,” that is, not as surprising and interesting as he expected at the Exploratorium. He explained that he visited the Exploratorium for his children, and they didn’t appear at all interested in this particular exhibit.

Choices about Engagement

All the interviewed respondents with substantial, extended, and very extended engagements told us about prior experience with the topic. In addition, parents indicated that they selected this exhibit because of their own prior knowledge and the opportunity to instruct their child. Not all individuals with prior knowledge had longer engagements, however. Leaving the exhibit appeared to be cued by (a) an outcome at the exhibit (either successful or unsuccessful) or (b) others in a respondent’s visiting group cuing him or her that it was time to move on.

One of the patterns we saw involved respondents walking up to an exhibit station, not being able to connect the circuit at the first station and quickly leaving. These initial unsuccessful experiences were most likely to occur when respondents began at the difficult station facing



away from the Exploratorium entrance. We saw this pattern several times. These briefer engagements ranged from 1.5 minutes to about 3 minutes. Compared to non-APE exhibits, where brief engagements may be entirely successful experiences for visitors, the shorter engagements at *Circuit Workbench* were generally associated with an unsuccessful outcome.

At the other end of the continuum, we observed three cases where respondents used all six stations and stayed extended periods of time. These longer cases included a 14-year-old boy alone, an adult male alone and a father/teenage son dyad. These engagements lasted from 11 to 23 minutes, and respondents did not choose to leave until they had successfully completed all the stations. After an 8-minute engagement, we asked a 10-year-old girl who had used the exhibit with her grandmother how she knew it was time to leave. She explained, “Once you figure out how it works, then you can go on to the next one.”

Another pattern we saw involved a successful outcome at the first station followed by termination of engagement. When asked why he left, one man explained, “I accomplished what I set out to do.” He added, however, that his children had selected the exhibit, and we had observed them leaving the exhibit before he did. In this and other cases, we could clearly see that another member of the visiting group cued the respondent to leave. In others, we saw adult males, whose groups were using another exhibit nearby, walk up, complete a circuit, and move on when his group left.

Tracking-and-timing data showed significant differences in the length of time spent at this exhibit by males and females, with females spending less time. Looking at the distribution of the individual times (Figure 2) indicates that females had more very short engagements, that is, less than 100 seconds (less than 2 minutes). One possible explanation is the topic of the exhibit. Greenfield (1995) found significant gender differences between the level of attraction between male and females on two types of exhibits. Females were more likely to use exhibits on the human body, and males were more likely to use exhibits on physics principles. Since we found that some of the shorter interactions at all APE exhibits were assessments and decisions about whether or not to commit to engagement, it is likely that this may have been what was happening during the shorter engagements by female respondents tracked at *Circuit Workbench*. It may also be that these shorter engagements in the tracking phase were connected with unsuccessful initial attempts at the first station.

Exhibit Design Characteristics

- At *Circuit Workbench*, the tasks involved had clear indications of whether visitors were able to make it work or not. This is similar to *Water Standing on Air*, but unlike that exhibit, the tasks themselves are intentionally challenging. This design characteristic appeared to produce some of the strongest emotional responses we saw. Among visitors who had success with the challenge, there were positive emotional responses. Among those who were unsuccessful, there was frustration. These emotional responses, both positive and negative, appeared strongest among male respondents.
- *Circuit Workbench* had six stations, three on each side of one exhibit unit. Each side had a relatively easy station, a station of medium difficulty, and a more difficult station. This meant that during the observations, one easy and one very difficult station were closest to the pathway visitors were using to move through the Exploratorium. This appeared to



lead several visitors to attempt the most difficult station first, with unsuccessful results, and then to stop using the exhibit.

- Flaps covering the explanation of how to “hook up” the circuits at each station were an important part of the exhibit’s challenge for many respondents. Several enjoyed having the solutions hidden so they could attempt the tasks on their own and test their skill and knowledge.
- Unlike all three of the non-APE exhibits, two individuals could manipulate exhibit components at the same time at one station. This enabled people to solve the task in a cooperative manner. While this was not the primary mode of use, it was possible and did occur.
- Respondents appeared to respond to various closure points at this exhibit. For several, an unsuccessful initial engagement prompted them to leave quickly. For others, establishing one or two connections appeared to satisfy their personal goals, especially if other members of their visiting group had left the exhibit or were waiting nearby. For a few, the exhibit appeared to challenge them to use each station successfully before leaving. Prior knowledge and confidence appeared to play an important role in when participants reached a closure point, and this appeared to be closely tied to the strong emotional response, especially among male respondents, elicited by the topic and design of the exhibit.

Downhill Race

We conducted eight observations and six interviews with respondents at *Downhill Race*.

We observed a wide range of groups using the exhibit including a male/female couple in their sixties, a 12-year-old boy alone, a adult female-child female dyad, a adult male-child male dyad, an adult female (grandmother)-male teen dyad, parents with 2 children under 6, an adult female with 2 female teenagers, and a large family group with children from 4 to about 12. Engagement times ranged from 1 to 17 minutes.

Exhibit Description

Downhill Race. This is an Investigation APE exhibit, where visitors race two of six possible disks down parallel tracks to see which one rolls faster. Most visitors approach the exhibit believing that heavier disks will roll faster. In fact, disks with more of their mass located near the hub roll faster than those with more mass located near the rim. Visitors race disks to figure out which variable – mass or distribution of mass – seems more important. Four of the disks have fixed masses; two have adjustable masses (i.e., the location of the mass can be altered). (*Going APE!* Exhibit Development Team, 2003b)

Physical Engagement

One pattern we observed (four cases) involved picking up wheels, placing them on the ramp, and observing the wheels roll down the ramp. Then weights on the wheels were adjusted or different wheels were selected, and the race sequence was performed again. In all but one group, respondents read the label at some point in the engagement, but only after running at least one race. In each case that the label was read, an adult either read it or prompted a child to read it. We observed weighing the wheels only twice. But in interviews, respondents appeared to have a good understanding of comparative weight; it appears that respondents were judging



comparative weight by holding the wheels. These cases ranged from 8 to 17 minutes and involved a boy alone, a family group with 4 children, and a grandmother-grandson dyad.

Another pattern involved parents with children under 6. In one case, the mother clearly directed the child not to push the wheels with her hands and told her what to do next. “Now you have to get a different one,” the mother said after they ran the first race. In another case, a father watched his young daughter pick up and roll a wheel, then called her name and they ran a race together. After that they quickly moved on. Each of these engagements with younger children was about 2 minutes long.

Intellectual Engagement

The range of intellectual engagement appeared to be related to prior levels of knowledge and the age of children in the visiting group.

In four of the eight observations, respondents clearly had a misconception of which wheel would win when they initially ran the race, and they left the exhibits with new understandings that they could articulate. These cases included a 12-year-old boy alone, children in a large family group, the child in an adult male-child dyad, and both members of the grandmother-teen dyad.

The interview revealed that the older couple that observed, read the label, and only briefly interacted with the exhibit components probably had prior knowledge of the concept before they walked up to the exhibit. The woman was an elementary teacher and liked the exhibit because it illustrated something she teaches. Their description of how they used the exhibit indicated that the man selected wheels that would best demonstrate what he had just read in the label.

In two other cases, the presence of children under 6 seemed to influence the nature of the experience. A mother engaging at the exhibit with her 6-year-old daughter appeared to be focused on getting her child to use the exhibit “correctly.” This mother came to the exhibit and left with a misperception, telling us that she was interested in the exhibit, but only as an opportunity to do something with her child. In the second case, the adult male in the group watched his small daughter roll a couple of wheels, read the label and then moved on. Both these engagements were about 2 minutes long and were focused on helping the child interact. These were similar to the child-centered engagements we observed at non-APE exhibits.

In one case, that of a large group of children led by an adult female, the primary intellectual engagement appeared to be assessing the exhibit and then deciding not to allow the children to engage.

Social Engagement

We observed a great deal of conversation at this exhibit, but it was difficult to hear most of it. What we could glean seemed related to three areas. The first type involved adjusting weights and explaining to another visitor what this would do. The second involved experimentation. For example, as one adult male stood at the top of the ramp with a boy about 12, each holding a wheel in place before starting the race, he suggested, “Let’s make a prediction!”

The third type involved prompting others, generally children under 6, to use the exhibit “correctly,” that is, not to push the wheels with their hands at the top of the ramp, interfere with a



race by pushing the wheels, or roll the wheel up the ramp from the bottom. As one mother said to her 6-year-old daughter, “You’re not allowed to push them. Keep your hands off.” But these “corrections” also were voiced between members of one group and another. We did not see a child younger than about 8 years old participating in the experimentation sequence.. This may indicate a bottom age range for using the exhibit to experiment to understand a concept. Younger children appeared more interested in simply rolling the wheels.

Conversations appeared to take place between members of the same social group and between people in different visiting groups. In several interviews, data collectors noted that they could not tell what group the respondent was with until the interview portion of the observation. In a few cases, children from one group paired up with a child of a similar age from another group to use the exhibit. We also observed children from one group reading the label when a parent in another group suggested it to his or her children.

Noise and crowds did not appear to affect the overall length of engagement with *Downhill Race*. In many instances, three or more social groups participated at this exhibit at the same time. Data collectors commented that respondents appeared determined to finish their engagement even with the crowds and the noise. This did not, however, appear to hold true with visitor groups that included younger children. When it was noisy and crowded at *Downhill Race*, most of those groups chose not to engage with the exhibit. We do not know if this decision was made because of the perceived age appropriateness of the exhibit, the challenge of managing younger children in crowded conditions, or some other factor.

Emotional Engagement

Among respondents who committed to longer engagements (substantial and above), several reported feeling a sense of friendly competition at the exhibit. They also reported being attracted to the exhibit because it looked like a competition and then realizing that their predictions of which wheel would win were “incorrect.” Figuring out the physical principles was a meaningful experience because it contributed to being able to win the race. One 13-year-old boy, using the exhibit apart from his family group, commented that the exhibit

Made me feel a little competitive -- and it was just pretty fun. Adults would say it was like going to the horse races.

Members of adult-teen dyads were observed smiling, joking, and challenging each other’s predictions. One adult, however, told us that he found this exhibit “pretty tame” and named other, more exotic exhibits at the Exploratorium that he preferred. In summary, most visitors appeared slightly energized after their experience and satisfied to have figured out the physical principles and won the race.

Choices about Engagement

In interviews, several respondents told us that they decided to use this exhibit because it looked exciting and fun. Among those with longer engagements, the cue to leave appeared to be when they had figured out, after successive trails, what variables were involved in “winning the race.”

The age level of younger children in the group appeared to play an important role in choices about whether or not to use the exhibit. One observation involved an adult woman assessing the



crowd and the nature of the exhibit and deciding not to participate. We were not able to interview this woman but data indicated that this was likely a child-management issue.

Among those who did participate briefly with their young children (6 and younger) the focus appeared to be on helping the children use the exhibit “correctly.” Younger children without direct adult supervision appeared to enjoy pushing the wheels up and down the ramp with their hands and observing the speed and pull of gravity. When the exhibit was being used by someone else, this interfered with running the races, and the smaller children were corrected by parents or other visitors and often moved out of the way.

In a few cases, crowding and/or the necessity to use this exhibit with people from other visiting groups appeared to be a factor in the nature and length of the engagement. One older couple stood watching other visitors for a couple of minutes and read the label. When they could find room at the exhibit, the man picked up two wheels, ran the race once, said something to the woman, and they moved on. This interaction was about 4 minutes long.

Exhibit Design Characteristics

- *Downhill Race* allowed multiple visitors to directly interact with exhibit elements at the same time. Two individuals were able to prepare wheels, stand at the top of the ramp, and begin races. Others were able to stand nearby, briefly wait their turn, and observe. While turn-taking behavior was required to use the exhibit in crowded conditions, the wait time appeared reasonable to most people. This capability enabled people to run several iterations of the race to change the variables, test their hypothesis, and figure out the physical principles. This capability contributed to the highly social nature of the exhibit, both among members of the same visiting group and between members of different social groups. Even people using the exhibit “alone” had highly social experiences with both cooperative and competitive elements.
- Children younger than about 10 did not appear to understand the central design idea of this exhibit, that is, running multiple races to test different variables. For younger children, simply observing and moving the wheels was interesting and enjoyable, but this interfered with the use of the exhibit as an experiment by older visitors.
- Respondents quickly assessed the invitation of the exhibit as a race. In interviews, people said that this was one reason they had decided to try the exhibit. It “looked interesting and fun.”
- For respondents with longer engagements, it appeared clear that the weights on the wheels could be moved from inner to outer positions. With no help from the labels, people quickly caught on that they could manipulate this variable easily.
- Few respondents appeared to use the scale to weigh the wheels; however, in interviews the impact of the weight variable was clearly understood. It appeared that this variable was assessed by judging comparative weight while holding the wheels.
- The placement of the label allowed people to test their ideas first and then refer to the information. Only one group we observed read the label before using the exhibit, and this was an older couple waiting to participate during a crowded time. Generally, we observed adults reading the label themselves or prompting young people to do so. Observations showed that this was done at important points in the interaction and enabled individuals to apply the information to solve the problem.



- For respondents who committed to multiple races, this exhibit appeared to have a clear closure point. When individuals had figured out how to manipulate the variables to win the race, they left. Unlike *Circuit Workbench*, gender did not appear to play a role in the intensity of emotion connected with this exhibit.
- When group activity was focused on children 6 and under, the closure point appeared to be when the child had run a single race “correctly,” that is, starting the wheel at the top of the ramp with out pushing and without interfering with its progress down the ramp.

Ice Painting

At *Ice Painting*, we conducted 12 observations and eight interviews. Engagement times ranged from 1 to 11 minutes. Group types observed using the exhibit included 4 adult male/female couples, 2 adult-teen/child dyads, and larger groups of 3 or more. No one was observed using the exhibit alone.

Exhibit Description

Ice Painting. This Observation APE exhibit presents ice that is lit up from underneath. When visitors look at the ice through polarizing filters, they see extraordinary colors and crystalline patterns. Visitors can manipulate the ice by melting it with their hands, or by melting larger parts of it with a water sprayer that is part of the exhibit. After a few minutes, the water will refreeze, and visitors will be able to watch the crystalline structures form before their eyes (*Going APE!* Exhibit Development Team, 2003b)

Physical Engagement

Among cases with longer engagements (4 minutes or more), respondents used almost all of the exhibit components. Most read the label at some point, but generally after an initial hands-on interaction. Respondents, who often waited for seats to open up around the exhibit, appeared to begin engagement in a variety of ways, for example, looking through the polarizers, touching the ice, picking up the spray. People using the exhibit together appeared to change seats to get different vantage points or to look at something in a filter that someone else had adjusted. In several cases, visitors who had been using the exhibit explained to recently arrived visitors that they needed to “wait for the ice to freeze” and look through the polarizers to see all the colors. Both during and after ice formation, adults touched the ice to melt it with their fingers. Children were sometimes corrected for this behavior.

We saw one very interesting self-generated behavior: A father in one group stacked the polarizing filters on top of each other to block out the light. The whole family of five then clustered their heads around the filters to look through them. The man later wryly explained that he knew this would work because he had been a physics major for a short time.

Intellectual Engagement

At *Ice Painting*, respondents with longer engagements appeared to make connections to other phenomena in their lives and to leave the exhibit with questions. Connections to other phenomena included the polarizing properties of sunglasses (most frequently cited), the appearance of ice under a microscope (adults), and the rainbow patterns oil makes floating on water. This indicated that people were making connections between the phenomenon in the exhibit and their existing knowledge and experience. Several adults noted that the exhibit was



about the structure of ice crystals and had given them an opportunity to both see and feel them forming. Both children and adults had questions after leaving the exhibit. They wondered where the colors came from when they looked at the ice through the polarizers, and several speculated on why temperature melted and changed the ice crystals.

Another intellectual activity at the exhibit for adults appeared to be assessing the value and appropriateness of the exhibit for the children in their group. One mother, a physician visiting with three teenage boys, stated positively:

It takes a very simple principle about states of matter and crystallization – it’s something that they study at all levels – elementary, middle school, even college and in a simple way made a creative hands-on display.

Yet the open-ended nature of the exhibit seemed to make the experience “less valuable” to a few respondents. A father, whose wife and teenage daughters had been at the exhibit for several minutes before he arrived, said that he picked the exhibit because it had a “verbal description.” When he arrived, he read the label aloud and began directing the others’ participation. In the interview, he told us the label did not have enough information and he still was not sure, after using the exhibit, what they were supposed to accomplish. In another interview, the respondents said that they would have liked more information in the label.

While some parents approached the exhibit and decided not to commit to a longer engagement because they judged that it was not appropriate for their younger children, we observed more than one group with children of similar ages who used and enjoyed the exhibit. We did not determine the basis on which these age-appropriate decisions were made, that is, if the exhibit was not appropriate intellectually, if manipulating it was considered beyond the children’s physical capability, or if the parents were concerned about their children’s behavior with other visitors at this very social exhibit.

Social Engagement

Like *Downhill Race*, using this exhibit was a very social experience. But where we observed both cooperative and competitive behaviors at *Downhill Race*; at *Ice Painting* the nature of the experience was almost entirely cooperative. Interaction took place among members of the same social group and among members of different social groups using the exhibit at the same time. The exhibit appeared to prompt a great deal of conversation.

In several of the cases, we observed members of more than one social group using the exhibit together. In one case, the mother in the family that was being observed brought a child from another group into the engagement and guided his activity by telling him he needed to leave the ice alone so he could watch the ice crystals form. In two cases, women from groups leaving the exhibit explained how it worked and shared their experiences as the next group walked up and sat down. One told members of the next group “Wait and watch it freeze! It’s cool.”

It appeared, from observation, that there was a great deal of conversation at the exhibit. Respondents seemed to share with others when they observed something. A typical remark from a young man was, “Wow – that’s incredible.” People were also seen and heard prompting each



other to look through polarizers or to read the label. More than once, the label was read aloud to all members of the group at the exhibit. In longer engagements, we also heard people speculating on how long it would take for the ice to freeze.

People took turns to use the exhibit, and when visitors who were using the exhibit noticed others waiting, they decided to leave.

Emotional Engagement

There appeared to be a range of emotional responses during and after using *Ice Painting*. During the longer engagements, we observed a great deal of smiling and laughing. For a few people, especially those who had never seen water freeze before, the experience was somewhat intense. One teenage male told us,

It kind of shocked me to find out it was going to be an exhibit like that here. But we got to watch ice freeze.

Other respondents we talked with about their experience at *Ice Painting* used words that indicated an aesthetic, sensual, and pleasant experience.

It was fun. It was beautiful. The ice crystals, the colors in the ice crystals were beautiful. I think it is a great exhibit. It's the only time I've seen that kind of exhibit – it's sort of, each crystal is different, each time you do it will be different.

I wasn't thinking. I just watched the ice freeze.

A man from Germany explained why he liked the exhibit,

And of course, everything that you do here has that quality of exploring for yourself, anyway. And what I found amazing was that you could touch the ice and you could actually feel the structure [as] it was . . . taking shape. You go over the thing and [it] lets you feel the [pattern of the crystals]. It was an amazing . . . discovery and [I] was very surprised to see [the crystals] grow. It was a little like seeing [a] jet in the sky. I mean, shapes slowly [developing].

Unlike at *Circuit Workbench*, we found very little frustration at this exhibit. When asked if they felt pressured when others were waiting, people explained that they saw a clear cycle in the exhibit (waiting for the ice to freeze) and this provided a reasonable closing point. So they did not feel pressured to leave until they were finished.

The only respondents who appeared displeased at this exhibit were the parents of very young children, who judged it inappropriate and left quickly, and a few who wanted more didactic information in the label.

At *Ice Painting*, we encountered the most unusual memory and connection to an exhibit in the study. A woman, visiting with her mother, stepfather, and daughter, told us that the colors in the exhibit brought to mind a visit to the Exploratorium when she was 7. She had come with her mother's boyfriend, who had given her LSD for the first time. The colors in the exhibit reminded



her of that childhood experience. She had mentioned this memory at the exhibit, and it made her mother quite uncomfortable.

Choices about Engagement

Several of the shorter engagements observed at *Ice Painting* were by people apparently assessing the exhibit and deciding either to not use it or to not wait to use it. Two of the shorter engagements, 1 to 2 minutes, involved children under about 7. In one observation, parents with a boy about 3 and a girl about 5 approached the exhibit. The mother sprayed water on the surface and then both parents lifted the children to look through the polarizers. The father leaned over and read the label, nodded to the woman, and the group left the exhibit. In the interview, the father told us that he concluded that the exhibit was not good for the smaller child, but that he thought it might be okay for the girl. This was another example of parents with younger children assessing exhibits for their appropriateness. This was similar to the behavior and judgment of parents with younger children at *Downhill Race*.

Other shorter engagements appeared to occur when group approached the exhibit as another group was waiting for the ice to freeze. When the first group had control of the sprayer, the second group would watch briefly and leave. However, when two groups started using the exhibit at the same time, both stayed for a considerable length of time.

The closure point in the experience among longer engagements appeared to be when the ice had frozen and members of the social group had all had the opportunity to view it in the polarizers. When asked why they left when they did, one visitor explained, "We— I think we went once through the whole cycle. We melted it all the way. I mean, once you [spray and melt it] when everything became ice again, it was time to leave."

In several instances, adults indicated to others in their group that they needed to end the engagement so others could use the exhibit.

Asked when his group decided to leave, one man said, "There were people behind us that wanted to watch and stuff."

Exhibit Design Characteristics

- People we spoke with clearly understood that the main idea of this exhibit was for them to observe and play with the phenomenon. Waiting for the water to freeze provided a cyclic nature to the experience that provided closure, but left questions.
- The central design concept of this exhibit, observing and exploring, did not involve "correct" use of materials or the exhibit to reach an outcome. This meant that younger children could participate with the larger family group, and even other visiting groups, without interfering with the experience of others.
- The design of *Ice Painting* appeared to elicit very different emotions from those we observed and spoke with at *Circuit Workbench* and *Downhill Race*. Where the challenge at *Circuit Workbench* was rather intense and sometimes frustrating, and *Downhill Race* elicited friendly competition, *Ice Painting* appeared to elicit wonder and amazement. These emotions were generally mild, but in a few cases rather intense.



- *Ice Painting* was designed so that four or five people at a time could interact physically with an exhibit component. We observed the exhibit being used easily by several members of larger visiting groups and by more than one smaller social group at one time.
- The physical arrangement of the exhibit, with several stools around the platform and visitors facing each other, seemed to invite and facilitate group interaction.
- The stools around the platform surface appeared to limit the number of people who tried to use the exhibit at one time, preventing people from crowding in and interfering with the experience of others.

We observed at least one member of most groups reading the label, which appeared to be conveniently placed. A few people wanted more label information about the phenomenon.



CONCLUSIONS

After Phase 1 of this summative evaluation study, we can draw some conclusions about how visitors engaged differently at APE exhibits and non-APE exhibits we observed. In addition, we found that the way visitors made choices about whether or not to engage differed between the two types of exhibits. We also found evidence that the choice about ending engagement was a substantially different process at APE exhibits than at non-APE exhibits. These patterns in the data provide the groundwork for a useful conceptual framework and questions for Phase 2 of the study.

We characterized differences between APE and non-APE exhibits within the framework of six perspectives: (1) time of engagement, (2) physical engagement, (3) intellectual engagement, (4) social engagement, (5) emotional engagement, and (6) choices about engagement. Time data is a useful indicator that visitors are engaging at APE exhibits differently than non-APE exhibits. Among the other perspectives, we found that the analysis of emotional engagement provided some of the most useful insights into what is going on with visitors at APE exhibits. Visitors had substantially different types of emotional responses and satisfaction at APE exhibits than at non-APE exhibits. The nature of these responses provided particular insight into their intellectual process.

Time of Engagement

Data clearly indicated that, on average, respondents spent longer times at APE exhibits than at non-APE exhibits. It must be remembered, however, that mean comparisons hide important differences in museum exhibit holding-time data. The most important difference we found between APE and non-APE exhibits was the range of engagement times. For example, the range at *Bubble Suspension* was 3.7 minutes, whereas at *Circuit Workbench* the range was 15.1 minutes. In addition, the standard deviations of non-APE exhibits were smaller than for APE exhibits. This tells us that some visitors appeared to recognize the opportunity for prolonged engagements at APE exhibits and to accept the invitation. The wide range also included many instances of brief and very brief engagements at APE exhibits. This indicated that some people (a) did not recognize the opportunity or (b) decided not to accept the invitation. Conclusions related to how visitors decided to begin and end engagement provides further insight into these questions that emerged from time data.

Emotional Engagement

One interesting finding that emerged from the emotional engagement data was the identification of what we are calling the *driving question*. A driving question was the initial thought that visitors were thinking about when they approached an exhibit. These driving questions tended to be prompted by the exhibit design. For example, for all three non-APE exhibits, the driving question could be summarized as, “What’s going on here?” The related emotional response was surprise and satisfaction. In interviews, most respondents who had used *Bubble Suspension* commented on their surprise about the bubbles floating. At *Touch the Spring*, comments focused on the surprise of the spring not being there when they tried to touch it. At *Water Standing on Air*, respondents who were not frustrated by the exhibit were delighted with the counterintuitive idea of water actually standing on air. Especially with these classic Exploratorium exhibits, it is



useful to remind ourselves that visitor response to the “trick” and “illusion” of counterintuitive phenomena is consistently positive, pleasant, and playful. A possible reaction could have been anger or defensiveness, but this was not the case. Based on their responses, the relationship between visitors and the exhibits can be described as trusting and good natured. A possible reaction to being tricked or surprised could have been to be angry or defensive, but this was not the case. Moreover, since curiosity about the phenomena could not be satisfied by observation, it also provided a way to explain the frequent label reading we observed at non-APE exhibits.

In contrast, at each of the APE exhibits the emotional response and we suspect the driving questions were different. The driving question at *Circuit Workbench* appeared to be the personal challenge “Can I do this?” Respondents with longer engagements were highly satisfied and proud of themselves. They often remarked that they had rarely had to lift labels to find the solutions. Among visitors with shorter engagements, we found injured pride and some discouragement. For example, two engineers appeared affronted that they could not quickly connect the circuits at the first station they encountered. The nature of this exhibit appeared to bring out some very strong emotions specifically related to competence and mastery. This type of driving question is closely related to issues of identity and personal competence.

At *Downhill Race*, respondents with the strongest emotional response appeared to be those with initial misconceptions. Similar to the non-APE exhibits, the driving question at this exhibit could be summarized as, “What’s going on here?” This surprise was viewed among visitors with longer engagements as pleasant and playful. The emotional response at *Downhill Race* differed from non-APE exhibits in the type and nature of satisfaction. Satisfaction was based on visitors being able to figure out the reasons for their own misconceptions. Respondents, who said they had prior knowledge and clearly understood the principles, did not appear as enthusiastic or engaged as respondents with clear misconceptions. This indicated that the driving question at this exhibit might have been, “Can I figure this out myself?” Like *Circuit Workbench*, this exhibit seemed to challenge personal mastery as a way to motivate engagement and learning. Unlike *Circuit Workbench*, however, it didn’t exclude people with little prior knowledge. We found visitors understanding the concept for the first time and visitors who were connecting their understanding to everyday experience.

The primary emotional response at *Ice Painting* differed from that at the two other APE exhibits. It was related to the opportunity to closely view something beautiful and fascinating, that is, the formation of ice crystals. The emotion seemed to be similar to the aesthetic experience of viewing a beautiful natural setting or a painting. The highly social nature of this experience indicated that seeing “the thing” and calling other people’s attention to it added to people’s pleasure and amazement at the phenomenon. Like all the other exhibits in the study, except *Circuit Workbench*, the relationship between the individual and the phenomenon itself appeared central. In these terms, the driving question can be described as, “What fascinating aspect of this can I see and share?”

Physical Engagement

One of the assumptions we made in our initial research design was that an analysis of physical engagement would help us understand whether or not visitors’ use of the exhibit was guided by the exhibit or if behaviors were self-generated. Label use was central in this assumption.



In general, frequent early label use at non-APE exhibits appeared to have three functions: (1) drawing visitors' attention to the phenomena, (2) helping visitors use exhibit components, and (3) providing the most accessible strategy to answer the driving question. (Remember that non-APE exhibits were selected based on the criteria that observing the phenomena -- and not reading the label -- would provide little assistance in understanding the phenomena.)

The range of physical behaviors was consistent and typical among the three non-APE exhibits, following the "do, observe, and read" sequence described in the proposal for guided-discovery exhibits. We observed respondents using the exhibit, reading the label, and moving to end their engagement fairly quickly. Many of the people we observed appeared to glance toward the label at several points in their engagement.

The sequence of physical engagement at the APE exhibits was unique to the individual exhibit. Labels were often referred to later in the sequence of exhibit use, indicating that they served a different function from those in the non-APE exhibits. We concluded that at APE exhibits the labels seemed primarily to play the role of confirming what visitors had observed or figured out independently rather than providing them with the solution to their driving questions. In many cases, visitors appeared to use APE exhibit components with little assistance from the label, and in many cases they seemed to avoid the label until later in their engagements.

At longer interactions at *Circuit Workbench*, we usually observed a successful trial at the first station, followed by the use of at least two other stations. Respondents tended to move through a sequence of trials until the circuit at the station "worked." Then they would move on to a more difficult station. Shorter engagements often involved an unsuccessful attempt at the first station. Respondents in longer engagements rarely lifted label flaps until after they used the interactive elements. In shorter engagements, respondents often used the labels at the beginning of their engagement but sometimes did not return to the activity to attempt to connect the circuit.

At longer interactions at *Downhill Race*, we also observed repeated trials of the interactive. At this exhibit, respondents chose various wheels and adjusted their weights. They often read the label, but only after running the race at least once. Label reading was generally done by an adult or prompted by an adult. Shorter engagements and interrupted engagements at this exhibit appeared to involve groups with younger children.

At *Ice Painting*, longer engagements were related to the cycle of the water freezing and the opportunity for all members of the social group to use the polarizing filters. The group at the exhibit appeared to turn over after the cycle of (a) spraying the platform to melt the ice, (b) watching the water freeze (both with and without the polarizer), and (c) commenting on the ice crystals. In interviews some respondents noted that they had been alerted to this cycle label. Visitors at *Ice Painting* more frequently referred to the exhibit label than at the two other APE exhibits.



Intellectual Engagement

An important question in this study was whether visitors left APE exhibits with more questions on more varied topics than at non-APE exhibits. We did not find this to be the case, but the question remains open for exploration in Phase 2 of the study.

The data indicated that intellectual engagement at non-APE exhibits followed a similar pattern to that of physical engagement. Among respondents whose non-APE exhibit engagement followed the “do, observe, read” pattern, we found understanding, at some level, of the exhibit concept. But while the intellectual engagement at non-APE exhibits tended to focus on the nature of the phenomena, the intellectual engagement at APE exhibits seemed to be both phenomena- and process-oriented. If the central question at non-APE exhibits was, “What’s going on here?” and respondents could answer this by reading the label, each of the APE exhibits focused on a different question and required a different response.

At *Circuit Workbench*, respondents told us that their primary questions during their engagement were, “How do I make it work?” and “Can I make it work?” Many respondents with longer engagements had prior experience with the topic, and the intellectual activity appeared to be to accept the challenge to apply their knowledge to the situations in the exhibit. We found few visitors leaving this exhibit with questions about the exhibit topic. There were indications that this may be because the question they were asking was, “Can I make it work?” and they answered this question through successful or unsuccessful engagement with the exhibit.

At *Downhill Race*, almost all of the respondents we interviewed with longer engagements said they started the engagement with the idea that the exhibit was a competition. This indicated that their initial question was, “Can I win?” However, when they realized they had a misconception about which wheel would win, the point of the engagement changed to trying to understand the nature of the phenomenon. In interviews, respondents appeared to have new understandings of the phenomenon and to be incorporating these new understandings into their existing knowledge of spinning ice skaters and wheels on racing cars.

At *Ice Painting*, among longer engagements, respondents appeared to simply enjoy the process of observing crystals form and seeing the colors through the polarizing lenses. Respondents connected the experience to their everyday life (ice cream freezing, wearing sunglasses). We did find people leaving this exhibit with questions, primarily about how polarizing lenses work and why temperature changes how water looks in various states.

Social Engagement

At non-APE exhibits, we frequently found that the dyads we had observed were members of larger social groups visiting the Exploratorium. We observed other members of groups waiting nearby or even calling to people using an exhibit to “move on.” We frequently heard in interviews that tourists and infrequent visitors ended engagements because they wanted to see all (or at least most of) the exhibits at the Exploratorium. It appears likely that the non-APE exhibits in the study -- where only one visitor at a time could easily interact with exhibit components -- support this tendency of social groups to split up into singles and pairs to use exhibits. We did,



however, also note this tendency at *Circuit Workbench*, where individuals using the exhibit left in response to pressure from others in their social group.

At two of the APE exhibits, social interaction appeared to prolong engagement but by different means. At *Downhill Race*, respondents appeared to work independently or with one other person. But the opportunity for multiple members of a visiting group to interact simultaneously may have allowed individuals to complete their engagement without the pressure of other members who were ready to move on. We did see a conflict between the use of the exhibit by older children and adults, who wanted to run the race and solve the problem, and younger children, who pushed at wheels with their hands and pushed wheels down the ramp. While this was age-appropriate behavior for younger children, it interfered with the use of the exhibit for other people. At *Ice Painting*, the design of the exhibit allowed larger groups to participate together without young children's presence conflicting with older group members' engagement.

Another social characteristic shared by both APE and non-APE exhibits was "turn taking" by visiting groups using the exhibits. Some engagements at both types of exhibits appeared to end with pressure from other groups. But at both types, groups appeared to hold their space until they reached closure.

Choices about Engagement

One interesting set of findings involved how respondents made choices about their engagement at exhibits. At APE exhibits, we observed what appeared to be decisions not to engage at the exhibits. Other observations were clearly ended prematurely when compared to longer engagements.

At *Circuit Workbench*, respondents' prior experience appeared to be strongly associated with an interest in using this exhibit. Unsuccessful initial trials were also connected with decisions to leave the exhibit. The other factor in ending engagement appeared to be signals from other members of the respondents' groups.

At *Downhill Race*, we observed what we assumed to be parents with younger children deciding not to engage at this exhibit. But we rarely saw someone leave after he or she had committed to an engagement, and we observed a number of intact visiting groups participating at this exhibit simultaneously, something rarely observed at non-APE exhibits. Pressure by other group members to leave appeared less frequently than at *Circuit Workbench*.

At *Ice Painting*, we have little that tells us why respondents decided to use this exhibit. Some parents of younger children assessed the exhibit by briefly interacting and then reading the label and deciding not to continue the engagement. As we conducted this study, a question emerged about how and why parents are deciding not to interact at some APE exhibits with younger children. While the data from this study did not clearly answer this question, there were indications that it might have to do with the content of the exhibit. For example, the content of *Ice Painting* perhaps is more appealing to younger visitors than the content of *Circuit Workbench*, where younger children sometimes got "overrun" and corrected. A similar behavior may also be taking place at *Downhill Race*.



Like *Downhill Race*, we observed few socially interrupted engagements at *Ice Painting*. Respondents -- especially those who committed to engagement by sitting down on the stools and spraying the platform -- remained at the exhibit even when other visitors were waiting.

Exhibit Design Characteristics

Non-APE Exhibits

- At each of the non-APE exhibits, the conceptual design of the exhibit appeared to fit the guided-discovery pattern described in the *Going APE!* proposal. The best indication of visitors' driving question was revealed in their statements about the emotions they had at the exhibit. These statements were generally directly related to the surprising phenomenon around which the exhibit was developed.
- At two of the three non-APE exhibits, only one visitor at a time could easily interact with exhibit components. This exhibit design characteristic appeared to be connected to the numerous dyads using the exhibits and to the tendency for visiting groups to separate to use exhibits.
- Both *Bubble Suspension* and *Touch the Spring* were difficult to use incorrectly. Respondents appeared to understand what to do quickly. We did observe some people having difficulty at *Water Standing on Air*. Those respondents who had difficulty clearly understood what to do and turned the tube several times, but a few were unsuccessful at getting the exhibit to work.

APE Exhibits

- Like non-APE exhibits, the conceptual design of each exhibit appeared to elicit similar patterns of engagement. The driving question presented by each of the APE exhibits, however, was specific to that exhibit.
- All three APE exhibits allowed the simultaneous use of exhibit components by more than one member of a social group. It appears that this may be one factor in the longer engagements we saw at *Downhill Race* and *Ice Painting*.
- All three APE exhibits provided tools for visitors to use to construct, investigate, or observe. Visitors quickly understood the purpose of these tools and used them in appropriate ways to answer the driving question presented by the exhibit.
- When offered the opportunity to explore the driving question through active engagement, some visitors committed to the activity and exhibited a wide range of physical behaviors that appeared directly connected to intellectual activity.

Complete and Incomplete Engagements

Analysis of the engagements in the previous section showed that at both non-APE and APE exhibits, some engagements appeared to be complete while others appeared to be incomplete. By this we mean that some visitors never really began an engagement. In other cases, engagement following similar patterns to longer engagements appeared to end prematurely because of social factors or unsuccessful outcomes at the exhibit. In each of the case studies for individual exhibits in the previous section, we described some consistent patterns of engagement when respondents finished their exhibit experience. But in other cases, they appeared to either (a) make a choice not to commit to the engagement or (b) leave before completing the experience as designed.



Complete engagements appeared to have characteristic beginnings, middles, and ends. At both APE and non-APE engagements, the beginning of the engagement appeared to be the visitor's recognition of a driving question. The middle of the engagement involved strategies and efforts to answer this question. At the end of the engagement the question was successfully answered and there appeared to be positive intellectual and emotional impacts.

Incomplete engagements appeared to end at either the beginning or the middle of the engagement. At the beginning, the driving question appeared not to be recognized or, in some cases, was not strong enough to compete with other visitor motivations. In the middle, respondents appeared to be working to solve the conflict but either had difficulty with their effort to resolve the conflict or were interrupted in their attempts by some external force. In incomplete engagements, the intellectual impact appeared to be little or no change in understanding, or confusion. The emotional impact was observed to be of one of three types: (a) some positive, (b) negative, or (c) little emotion at all.

It should be noted that from the visitor's perspective, incomplete engagements might not be unsuccessful. For example, at the non-APE exhibit *Bubble Suspension*, several of the respondents we observed followed a similar pattern. They approached the exhibit, glanced at the label, blew bubbles, watched the bubbles moving down the tube and floating, and then read the label again. In interviews they explained to us that the carbon dioxide from the dry ice was causing the bubbles to float, information only available by prior knowledge, from another visitor, or from the label. They told us that the exhibit was "cool," and they appeared to have enjoyed the experience. We can label this a complete experience, and obviously a successful one from the visitor's perspective, as well as from the museum's. In another interaction at the exhibit, a 6-year-old girl simply enjoyed herself blowing bubbles. While she enjoyed the experience, she never "got" the driving question presented by the exhibit, that is, surprise at the bubbles floating on a layer of carbon dioxide. In this sense we can say that this was an incomplete engagement. This may not have been an unsuccessful engagement for the child, but it was incomplete in the design sense.

At the APE exhibit *Downhill Race*, we observed a 12-year-old boy alone having what we can call a complete experience. In the interview, he told us that he walked up to the exhibit because it looked "fun." He soon realized that the wheel that he thought would reach the bottom of the ramp first did not. This respondent clearly recognized the driving question. This was the beginning of his engagement. Next, in the middle, he started an iterative process of running races, each time selecting different wheels and adjusting weights to try to figure out what was going on. During this process he talked with other visitors and read the label at the suggestion of someone's mother. This was the middle of the engagement. After several races, he told us he knew which wheel would win. After running a couple of additional races just to make sure, he left. This was the end of the engagement.

At *Downhill Race*, we also observed some incomplete engagements. One involved a woman with five children who approached the exhibit, picked up a wheel, put it down, and then nodded to the children in her group to move on. She refused an interview because the children were tired and they wanted to see all the exhibits at the Exploratorium. While it would have been useful to interview her about her thinking, it was clear that this was an incomplete experience. This



engagement appeared to break down in the beginning when, for whatever reason, she made a choice not to engage further. For this woman, this may not have been an unsuccessful engagement. We can speculate that she may have accomplished her own goal, that is, seeing all the exhibits or not getting the children in her group overly tired. But the engagement as designed was incomplete.

The data from this study indicated that the driving question presented to visitors at non-APE exhibits appeared to be fairly consistent and was comprehended quickly. To resolve these conflicts, visitors observed the phenomena, and when they could not understand what was going on based on their observation, they turned to the label for an explanation. The end product of this experience was information, that is, scientific information that someone else developed. In current discussions of science we often hear about definitions of science as a product -- knowledge -- as well as science as a process. In most cases at the non-APE exhibits we observed, visitors had little accessible opportunity to observe, develop, or apply their own knowledge. We want to emphasize that we did encounter instances at non-APE exhibits where respondents observed phenomena extensively (for example, one woman at *Bubble Suspension*) or explored to confirm their hypotheses (for example, those respondents who reached under the exhibit at *Touch the Spring*). But these cases were atypical, and were often the reasons we were able to identify the consistency among the other observations.

In addition to the incomplete engagements at the APE exhibits, we also observed incomplete engagements at non-APE exhibits. There were instances at *Water Standing on Air* where respondents had little affect and, after brief engagements, moved on without reading the label and with minimal understanding of the phenomenon. An extremely long engagement at *Touch the Spring* among the Spanish teenagers was also considered incomplete. These respondents left the exhibit still curious about the phenomenon, and the basic driving question was never answered. At non-APE exhibits, there was often little difference in time between a complete or incomplete engagement at the same exhibit. In the instance cited at *Touch the Spring*, the incomplete engagement was actually longer than many of the engagements that were complete. Thus, time was *not* a good indicator of complete engagements at non-APE exhibits.

Time *was* a good indicator of complete engagements at APE exhibits. Shorter engagements at APE exhibits tended to be incomplete engagements associated with (a) decisions not to use the exhibit with younger children (tentatively at all three APE exhibits), (b) child-centered engagement with adults accompanying younger children, (c) social interruptions, and (d) unsuccessful initial outcomes.

Recommendations for Phase 2

The framework of complete and incomplete exhibits gives us a way to identify instances where visitors did and did not take advantage of the opportunities for extended engagement at APE exhibits. But it also opens the door to many questions that we cannot answer from the data collected in this study.

This study provides clear evidence that there is a difference in visitor engagement at APE and non-APE exhibits. It is possible to design exhibits that provide the opportunity for active prolonged engagement. But not all visitors accepted the implicit invitation to engage. We need to



understand more clearly why some visitors accepted this invitation and others did not. Obviously, some reasons for incomplete engagements may be beyond exhibit designers' control. A great deal of useful data in this study was collected from observations. The patterns of sequence of interaction at the two types of exhibits were clearly different. But we do not yet understand the process of intellectual engagement. It appears somewhat different at the three types of APE exhibits selected for this study. We need more detailed observation of conversations and interactions during engagements to understand if the nature of engagement is different, for example, at a construction APE exhibit and at an investigation APE exhibit. We also want to focus on helping visitors describe what they were thinking during the process of engagement at APE exhibits. If we can help visitors more clearly articulate their driving questions in intellectual as well as emotional terms, we can provide some very useful tools for the conceptual design of successful APE exhibits.



REFERENCES

- Going APE!* Exhibit Development Team. (2002). Draft coding schemes. (Unpublished communication to evaluators). San Francisco: The Exploratorium.
- Going APE!* Exhibit Development Team. (2003a) Criteria for selecting APE and non-APE exhibits. (Unpublished communication to evaluators.) San Francisco: The Exploratorium.
- Going APE!* Exhibit Development Team. (2003b) Exhibit descriptions. (Unpublished communication to evaluators). San Francisco: The Exploratorium.
- Greenfield, T. A. (1995). Sex differences in science museum exhibit attraction. *Journal of Research in Science Teaching*, 32(9), 925-938.
- Izard, C. E.; Kagan, J., & Zjonic, R. B. (eds.) (1984). Emotions, cognition and behavior: Based, in Part, on Workshops Sponsored by the Committee on Social and Affective Development during Childhood of the Social Science Research Council. Cambridge: Cambridge University Press.
- Lincoln, Y. S. & Guba, E.G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage Publications.
- Miles, M. & Huberman, A. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage Publications
- Perry, D. L. (1993). Beyond cognition and affect: The anatomy of a museum visit. *Visitor Studies: Theory, Research and Practice: Collected papers from the 1993 Visitor Studies Conference*, Birmingham, AL, 6, 43-47.
- Serrell, B. (1998). *Paying attention: Visitors and museum exhibitions*. Washington, DC: American Association of Museums, Technical Information Service.



APPENDIX A: TOPICAL FRAMEWORK *GOING APE!* SUMMATIVE EVALUATION PHASE 1

7/31/03

Overall Research Question

How do visitors engage differently at a good APE exhibit compared with a good non-APE exhibit? And secondarily, what are the design characteristics that seem to lead to these differences?

The findings from this first phase of the summative evaluation will inform the final design of the 30 APE exhibit units. It is anticipated that this evaluation study will illuminate preliminary understandings of (a) how visitors behave at APE exhibits and (b) the design characteristics that appear to facilitate and contribute to this behavior.

Physical Engagement

Time at Exhibit

1. What is the difference between how visitors spend time at APE exhibits compared with non-APE exhibits?
2. How long do visitors spend at the units?
3. What are the mean, median, mode, and range for each exhibit?
4. What are the mean, median, mode, and range for the APE exhibits as a group compared with the non-APE exhibits? Is this a statistically significant difference?
5. What types of visitors (in terms of ages, abilities, and background) spend different amounts of time at different exhibits?
6. To what extent and in what ways does crowding affect time at exhibit?

Range of Activities

1. What is the difference in the range of ways visitors meaningfully engage with APE vs. non-APE exhibits?
2. How many distinct activities does the visitor do at each exhibit?
3. What is the range of ways visitors engage at each specific exhibit?
4. In what ways and to what extent do they interact in meaningful ways at each exhibit?
5. Are there a set number of limited ways that most visitors tend to interact with each particular exhibit?
6. Which exhibits elicit the widest range of meaningful physical engagement? Which elicit more limited and predictable ways of interacting?
7. In what ways and to what extent do visitors primarily follow the instructions on the label at each exhibit?
8. In what ways and to what extent do visitors use the label as a jumping off point, but follow it up with generating their own activities?

Predictability of Activity

1. What is the difference in the predictability of ways visitors engage at APE and non-APE exhibits?



2. How predictable is visitor engagement at each exhibit?
3. What examples of unpredictable and yet meaningful interactions are there?
4. Which exhibits elicit the most predictable meaningful behavior and which the least?

Appropriateness of Activity

1. In what ways and to what extent do visitors participate in age/background/ability-appropriate activities at APE compared with non-APE exhibits?
2. How do different types of visitors engage with different exhibits?
3. What evidence is there that certain segment of the population are excluded from meaningfully participating with certain exhibits?

Further Exploration

1. In what ways and to what extent do visitors explore each exhibit after their initial questions are answered?
2. Under what conditions do they end their physical interaction and leave the exhibit?

Multiple Entry Points

1. In what ways and to what extent do different visitors enter the exhibit in different ways?
2. What are the various ways that visitors enter each exhibit?

Limitations

1. What are the limitations to meaningful physical engagement with each of the six exhibits?

What Else?

What else can we learn about how visitors physically engage with APE and non-APE exhibits?

Intellectual Engagement

Questions

1. In what ways and to what extent is the range of questions those visitors generate different between APE exhibits and non-APE exhibits?
2. What questions do visitors ask while they are engaged with each exhibit?
3. What questions do they leave the exhibit with?
4. In what ways and to what extent do visitors follow their questions with a range of follow-up activities? What is the nature of these follow-up activities?
5. In what ways and to what extent are the questions that visitors generate and visitors' follow-up activities similar?
6. In what ways and to what extent are the questions that visitors generate and visitors' follow-up unanticipated?
7. What is the nature of the questions? To what extent and in what ways are the questions an indication of open-ended exploration and discovery vs. developing an understanding of specific exhibit content?



Conclusions and Conceptual Understandings

1. In what ways and to what extent is the range of visitor understandings different between APE and non-APE exhibits?
2. What is the range of visitor understandings at each exhibit?
3. At which exhibits do visitors tend to develop similar and predictable understandings?

At which exhibits do visitors develop the widest range of conceptual understandings?

Metacognition

1. In what ways and to what extent are visitors to APE and non-APE exhibits aware of the scientific inquiry processes they are engaged in?
2. To what extent and in what ways do they reflect on these scientific inquiry processes?

Limitations

What were the limitations to meaningful intellectual engagement with each of the six exhibits?

What Else?

What else can we learn about how visitors intellectually engage with APE and non-APE exhibits?

Social Engagement

Questions

1. How does questioning behavior among visitors differ between APE and non-APE exhibits?
2. What questions do visitors ask each other?
3. What concepts and issues do visitors ask each other questions about at each exhibit?
4. In what ways and to what extent do visitors ask a range of questions at each exhibit?

Range of Focus and Viewpoints

1. What is the range of focus of visitor conversations at each exhibit?
2. To what extent and in what ways are the meaningful conversations among and between visitors focused on a range of visitor-generated issues and concerns?
3. What are the various viewpoints, opinions, and conceptualizations that are expressed at each exhibit?
4. How do these constructions differ among visitors to different exhibits?
5. To what extent and in what ways do visitor conversations indicate play, observation, investigation, and contemplation?
6. To what extent and in what ways do conversations tend to converge towards the creation of an exhibit-centered common understanding?

Types of Social Engagement

1. What is the range of types of social engagement that visitors demonstrate at each of the six exhibits?
2. Which of the types of social engagement are similar across exhibits? Which are different? In what ways and to what extent?



3. How do the various types of social engagement differ at specific exhibits, e.g. silence, teaching-learning, showcasing, watching, and observing another visitor?

Use of Exhibit

To what extent and in what ways do visitors socially engage with each other at the different exhibits during play, observation, investigation, and contemplation?

Limitations

What were the limitations to meaningful social engagement with each of the six exhibits?

What Else?

What else can we learn about how visitors socially engage with APE and non-APE exhibits?

Emotional Engagement

Source of Satisfaction

1. To what extent and in what ways do visitors derive their sense of satisfaction from the process of engaging with the exhibits vs. accomplishing an educational goal?
2. Which visitors participate in a flow experience, and under what circumstances? What is the nature of these flow experiences?

Limitations

1. What were the limitations to meaningful emotional engagement with each of the six exhibits?
2. In what ways and to what extent do visitors to these six exhibits feel frustrated and/or intimidated?
3. In what other ways and to what extent is the visitor experience compromised at APE and non-APE exhibits?

What Else?

What else can we learn about how visitors emotionally engage with APE and non-APE exhibits?

Exhibit Design Characteristics

1. What aspects of APE exhibits contribute to APE-like visitor engagement with exhibits?
2. What aspects contribute to meaningful physical engagement at APE and non-APE exhibits?
3. What aspects contribute to meaningful intellectual engagement at APE and non-APE exhibits?
4. What aspects contribute to meaningful social interaction at APE and non-APE exhibits?
5. What aspects of the exhibit designs contribute to meaningful emotional engagement including feelings of satisfaction and flow at APE and non-APE exhibits?
6. What aspects contribute to feelings of frustration and intimidation?
7. To what extent are visitors aware of the differences between APE and non-APE exhibits?

Do they recognize that APE exhibits are a qualitatively different type of experience?
What else can we learn about the exhibit design characteristics of APE and non-APE exhibits?



APPENDIX B: ATTRIBUTES OF VISITOR ENGAGEMENT AT APE AND NON-APE EXHIBITS

**Going APE! Summative Evaluation Phase 1
7/28/03**

Physical Engagement	
APE	Non-APE
Visitors will spend significantly longer periods of time.	Visitors will spend shorter periods of time.
The length of time visitors spend at the exhibit will not depend on their age, ability, or background.	Visitors will spend different lengths of time at the exhibit based on their age, ability, and background.
Visitors will do a number of different activities.	Visitors will do just a few activities.
Visitors will engage in a sequence of self-generated activities leading toward the solution of a problem or a discovery about a phenomenon.	Visitors will engage in a sequence of activities suggested in the label or implicit in the design of the interactive.
Visitors will demonstrate a range of different meaningful ways of interacting with the exhibit.	Visitors will engage with the exhibit in a limited number of meaningful but predictable ways.
Visitors will engage with exhibit in individualized ways appropriate to their age, ability, and background.	Visitors will engage with the exhibit in similar ways, regardless of their age, ability, or background.
Visitors will generate and pursue self-directed activities not mentioned in the labels.	Visitors will primarily do the activities suggested in the labels or implicit in the design of the interactive.
When visitors' initial questions and hypotheses are answered, visitors will pursue further exploration.	When visitors' initial questions and hypotheses are answered, visitors will leave the exhibit.
Visitors of various ages, abilities, and backgrounds will begin interaction at different points or with different activities (i.e., multiple entry points).	Visitors of various ages, abilities, and backgrounds begin interaction at points cued by the label or implicit in the design of the interactive. Most visitors begin their interaction with the exhibit at the same place.

Intellectual Engagement	
APE	Non-APE
Visitors will generate a range of meaningful questions about the exhibit content or phenomenon.	Visitors will ask a few limited questions about the exhibit content or phenomenon.



Intellectual Engagement	
APE	Non-APE
Visitors' questions will be followed by a variety of self-directed play, observation, investigation, and contemplation activities.	Visitors' questions will be followed by a limited range of activities prompted by the label or design of the interactive.
Answers to questions raised will be clearly tied to individual exploration and conversation with other visitors.	Answers to questions will be clearly tied to the exhibit.
Answers to the individual's questions will be articulated as a process of discovery or exploration.	Answers to questions will be articulated as a process of understanding a point communicated by the exhibit.
Visitors will articulate a wide range of appropriate conclusions and understandings based on their experience.	Visitors will articulate a limited range of appropriate conclusions or understandings.
Visitors' conceptual understandings of the phenomenon will display a range of individual constructions and conclusions.	Visitors' conceptual understandings of phenomena will display similar constructions and understandings of phenomena.

Social Engagement	
APE	Non-APE
Visitors will ask each other a range of interesting questions.	Visitors will ask each other a limited set of interesting questions.
Visitors' conversations will indicate play, observation, investigation, and contemplation.	Visitors' conversations will focus on the intended use or point of the exhibit.
Visitors' conversations will include discussions of multiple viewpoints, constructions, and understandings.	Visitors' conversations with others will include discussions of a single or primary point of the exhibit. Conversations will be convergent toward a common understanding.
There will be a range of types of social interactions including silence, teaching-learning, and showcasing.	Visitors will engage in a typical informal science teaching-learning exchange.
Visitors will challenge each other to engage with the exhibit in unique and interesting ways.	Visitors will encourage each other to use the exhibit in a prescribed way.

Emotional Engagement	
APE	Non-APE
Visitors will feel satisfied with the journey.	Visitors will feel satisfied when they "get it."
Visitors will experience a sense of flow. They will lose sense of time.	Visitors will enjoy completing a prescribed activity.



Attributes of Going APE! Exhibits

6/18/03

- Active prolonged engagement is accessible to visitors with disparate backgrounds.
- The exhibits engage visitors in multiple ways appropriate to their age and educational level.
- Visitors of different backgrounds are motivated to engage further at the exhibits.
- Visitors drive their own activity with limited or no frustration.
- Visitors are not overwhelmed by multiple options: They know where to start and how to continue.
- Visitors feel satisfied with the amount of guidance or explanation at the exhibits.
- Exhibits generate visitor-authored questions and activities.
- Visitors ask questions – of the exhibit and of each other.
- Visitors engage in activities that are suggested by labels but not fully directed by them, or are entirely independent of the labels.
- Visitors use the exhibit to find answers to their questions rather than solely seeking authoritative answers.
- Exhibits stimulate conversations among visitors at the exhibits indicating inquiry, exploration, play, observation, and contemplation.
- Visitors' conversations suggest a focus on scientific process skills.
- Visitors' conversations seem to differ in quality at APE and non-APE exhibits.
- Visitors achieve demonstrated cognitive or visceral understandings of the phenomenon.
- Visitors seem to be building or practicing skills in inquiry, exploration, play, observation or contemplation; and/or visitors seem to be constructing a conceptual understanding of the phenomenon.
- Visitor holding time increases at exhibits.
- Visitors spend more time at exhibits, and seem more engaged with them.



APPENDIX C: DATA COLLECTION AND DEBRIEFING PROTOCOL

Going APE!

Phase 1: Data Collection Protocol

Data Set: APE2 _____ Exhibit Name: _____

YYMMDD Your Initials

Data Collector: _____ Date: _____

Observation Start Time: _____

Reason for selecting respondent:

Social Group (describe):

Observation Notes:

Observation End Time: _____



Going APE!
Phase 1: Debriefing Protocol

Data Set: APE2_ YYMMDD Your Initials

Context:

Exhibit Name:

Data Collector:

Observation Start Time:

Observation End Time:

Total Time of Engagement:

Interview End Time:

Reason for selecting respondent:

Social Group (describe):

Narrative Summary of Observation

Narrative Summary of Interview

Reflection

What were the salient characteristics of the engagement in each of these areas?

Physical:

Intellectual:

Social:

Emotional:

To what extent and in what ways did the exhibit design influence the engagement?

Other Reflections:

NEXT STEPS:



APPENDIX D: TIME AT EXHIBIT – DETAILED ANALYSIS

Information from the tracking-and-timing study provided a picture of central tendencies that are helpful in comparing APE and non-APE exhibits.

Description of the Sample

A total of 89 respondents were tracked and timed. Of these respondents, 40 were male, 48 were female and the gender for one respondent was missing. Of the total sample, 22.5% were visiting alone and 77.5% were part of a social group; in addition, 31.5% were children under 13, 8.9% were teens, 42.7% were younger adults (20 to 40 years old) and 18.0% were older adults (over 40 years old).

Descriptive Statistics and Characteristics of Distributions for Individual Exhibits

Figure D.1 shows the descriptive statistics for individual exhibit units in minutes. Exhibits used in observational data collection are highlighted.

Figure D.1: Tracking-and-timing Data (in minutes)

Exhibit Name	Type	N	Mean	Median	SD	Range	Min	Max
<i>Circuit Workbench</i>	APE	35	3.3	2.5	3.4	15.1	0	15.1
<i>Downhill Race</i>	APE	51	1.7	1.3	1.6	7.5	0.1	7.5
<i>Floating Objects</i>	APE	49	2	1.3	1.7	6.5	0.2	6.7
<i>Ice Painting</i>	APE	26	1.4	1	1.2	4.9	0.1	4.9
<i>Bubble Suspension</i>	non-APE	36	0.9	0.8	0.7	3.7	0.1	3.7
<i>Circling Waves</i>	non-APE	29	0.6	0.4	0.6	2.6	0.1	2.7
<i>Liquid Litmus</i>	non-APE	26	1.3	1	0.9	3.5	0.1	3.6
<i>Rift Zone</i>	non-APE	60	0.8	0.6	0.8	4.6	0	4.6
<i>Touch the Spring</i>	non-APE	33	1.4	1.2	0.8	2.8	0.1	2.9
<i>Water Standing on Air</i>	non-APE	34	0.7	0.7	0.6	2.5	0.1	2.6

Each of these individual distributions is non-normal, reflecting the highly skewed data typical of time data at most museum exhibits. That is, the holding times at each exhibit contain a majority



of cases with rather short times and a few extremely longer holding times. With non-normal data, the median, or the point in the distribution below which 50% of the observations fall, is considered a better indicator of central tendency than the mean, which is sensitive to extreme scores. Note that the means of several of the distributions are somewhat larger than the medians. This is indicative of negatively skewed data; in other words, that there were many shorter holding times.

APE and Non-APE Scores

Figure D.2 shows the descriptive statistics for the average holding time at APE and non-APE exhibits. Two average holding times for each individual were calculated by totaling the time at APE or non-APE exhibits then dividing by the number exhibits at which the individual stopped. These can be considered an APE score and a non-APE score for each individual. Mean and median holding times for APE exhibits appear longer than for non-APE exhibits. The mean APE score was 132.3 seconds (SD=113.7) with a median of 108.0 seconds. The mean non-APE score was 51.1 seconds (SD=32.2) with a median of 49.3 seconds.

Figure D.2: Average Holding Scores at APE and Non-APE Exhibits in Seconds

	N	Mean	Median	SD	Range	Min	Max
Mean APE Holding Time	73	132.3	108.0	113.7	676.0	13.0	689.0
Mean Non-APE Holding Time	77	51.1	49.3	32.2	217.5	4.5	222.0

The shape and nature of these time distributions provide guidance on the types of inferential comparisons to calculate. But they also provide important information about the overall scale and nature of the use of APE and non-APE exhibits. The gap between the median and mean was much larger for APE scores than for non-APE scores. This indicates that the APE score distribution was highly skewed to the left and was non-normal. Examination of the non-APE score distribution shows that it is also non-normal; the distribution of non-APE scores has bimodal tendencies. These two distributions are shown in Figures C.3 and C.4.

The APE score distribution shows a greater frequency of shorter scores with fewer longer scores. The non-APE score distribution indicates there may be two groups within overall distribution: one with a mean score of around 20 seconds and another with a mean score of around 60 seconds.

A comparison of these two distributions helped us answer the question of whether or not respondents spent greater amounts of time at APE exhibits, on average, than at non-APE exhibits. The apparent differences in these distributions is most striking in the overall range of scores, with APE scores ranging from 13 seconds to 689.0 seconds (11.5 minutes), and non-APE scores ranging from 4.5 seconds to only 222.0 seconds (3.7 minute). But the median holding times (the point in the distribution below which 50% of the scores fall) of the APE and non-APE scores were much closer. The APE median was 108.0 seconds (1.8 minutes) compared to 49.3 seconds for non-APE exhibits. This means that 50% of the respondents spent an average of less

than 2 minutes at APE exhibits. This raises the important question: What is the nature of this type of shorter engagement at an APE exhibit?

A significant test was calculated to compare average times at APE and non-APE exhibits. Since these are non-normal distributions, a nonparametric test was used to compare the groups. We calculated a Wilcoxon Signed Ranks Test for two related samples. The groups were significantly different at the $p < .001$ level. This indicates that respondents tended to spend significantly longer times at APE exhibits than at non-APE exhibits.

Figure D.3: Distribution of Individual Averages (Scores) at APE Exhibits

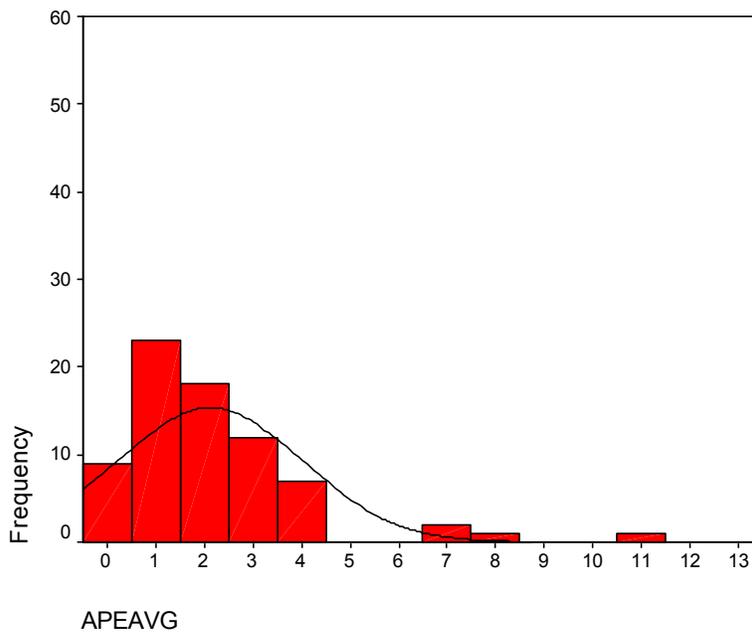
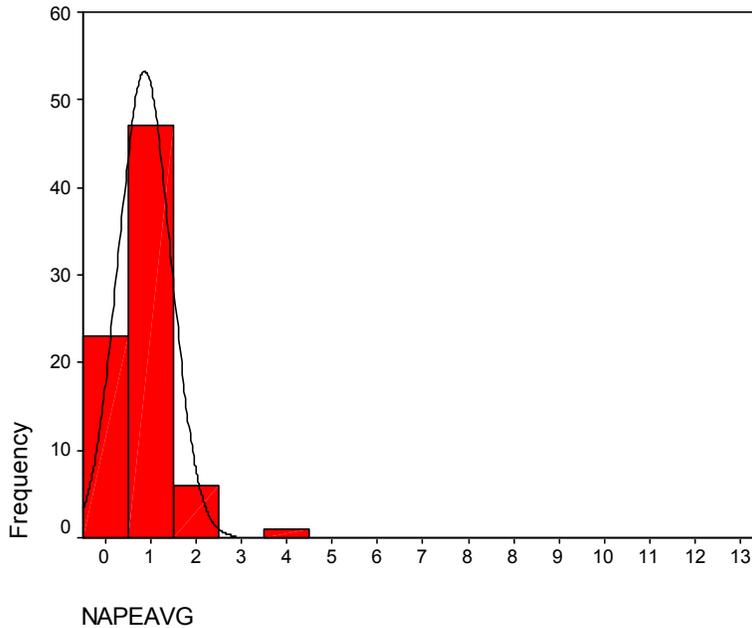


Figure D.4: Distribution of Individual Averages (Scores) at Non-APE Exhibits



We also calculated group comparisons for gender, age, and group size. Descriptive statistics for each of the groups in each comparison are shown below.

Figure D.5 APE Scores by Gender

APE Scores by Gender								
Gender	Mean	N	SD	Median	Grouped Median	Min	Max	Range
Male	148.0	33	113.0	124.0	124.0	17.0	483.0	466.0
Female	119.3	40	114.0	98.7	98.7	13.0	689.0	676.0
Total	132.3	73	113.7	108.0	108.0	13.0	689.0	676.0

Figure D.6 Non-APE Scores by Gender

Non-APE Scores by Gender								
Gender	Mean	N	SD	Median	Grouped Median	Min	Max	Range
Male	45.8	35	27.2	42.0	41.7	6.0	115.5	109.5
Female	56.8	41	35.1	55.5	55.5	14.0	222.0	208.0



Missing	4.5	1		4.5	4.5	4.5	4.5	0.0
Total	51.1	77	32.2	49.3	49.3	4.5	222.0	217.5

Figure D.7 APE Scores by Age Group

APE Scores by Age Group								
Age Groups	Mean	N	SD	Median	Grouped Median	Min	Max	Range
Children (<13)	167.7	21	122.1	128.5	128.5	40.5	483.0	442.5
Teens (13-19)	206.3	5	272.4	93.7	93.7	50.0	689.0	639.0
Younger adults (20 to 40)	103.8	33	75.9	91.0	91.0	13.0	270.0	257.0
Older adults (>40)	119.9	14	72.6	116.0	116.0	17.0	266.3	249.3
Total	132.3	73	113.7	108.0	108.0	13.0	689.0	676.0

Figure D.8: Non-APE Scores by Age Group

Non-APE Scores by Age Group								
Age Groups	Mean	N	SD	Median	Grouped Median	Min	Max	Range
Children (<13)	41.8	23	23.9	38.0	38.0	7.0	109.3	102.3
Teens (13-19)	48.8	7	22.9	50.6	50.6	16.0	76.0	60.0
Younger adults (20 to 40)	59.6	32	39.7	58.1	57.6	4.5	222.0	217.5
Older adults (>40)	48.3	15	26.8	53.0	53.0	6.0	102.2	96.2
Total	51.1	77	32.2	49.3	49.3	4.5	222.0	217.5

The mean APE score for males was 148.0 seconds (SD=133.0) with a median of 124.0 seconds. The mean APE score for females was 119.3 seconds (SD=114.0) with a median of 98.7 seconds. These means were compared using a nonparametric test, the Mann-Whitney U for independent samples. These apparent differences were not significant.

The mean non-APE score for males was 45.8 (SD=27.2) with a median of 42.0, and the mean female non-APE score was 56.8 (SD=35.1) with a median of 55.5. These means were compared using a nonparametric test, the Mann-Whitney U for independent samples. These apparent differences were not significant. In summary, we found no significant difference by gender in the time use of APE and non-APE exhibits.



We also compared APE and non-APE scores by age groups. Age data collected in the tracking-and-timing study was recoded to provide a more equal distribution of size. Four groups were created. For APE scores the mean for children (under 13 years old) was 167.7 seconds (SD=122.1) and a median of 128.5 seconds; for teens (ages 13 to 19) the mean was 206.3 (SD=272.4) and a median of 93.7; for younger adults (ages 20 to 40) the mean was 103.8 (SD=75.9) and a median of 91.0; and for older adults the mean APE score was 119.9 (SD=72.6).

There are some apparent differences with shorter stay times at APE differences [among teens and younger adults. For non-APE scores, the means and medians were much more consistent. The mean for children was 41.8 seconds (SD=23.9), for teens the mean was 48.4 (SD=22.9), for younger adults 59.6 seconds (SD=39.7), and for older adults the non-APE mean score was 48.3 (SD=26.8). Kruskal-Wallis Tests for four independent samples were calculated for both APE scores and non-APE scores. Apparent differences for neither APE nor non-APE scores were significant. In summary, age did not seem to make a difference in exhibit use at either APE or non-APE exhibits.

We also looked for differences in group size. APE score means ranged from 89.9 seconds (SD=105) for groups of two to 154.3 seconds for groups of five or more. These differences were not significant. Non-APE mean scores ranged from 34.0 (SD=29.5) for individuals to 55.4 seconds (SD=23.4) for groups of five or more. The differences among group size were not significant.

Individual Exhibit Comparisons

Finally, we compared individual exhibit holding times by gender, age, and group size. We used a nonparametric test for this non-normal data, the Kruskal-Wallis Test for independent samples. We found only one significant difference. Male and female visitors at *Circuit Workbench* had significantly different times of engagement $p < .05$. Figure 7 shows the male mean was 4.2 minutes (SD=3.4), and the female mean was 2.4 (SD=3.2).

Figure D.9: Circuit Workbench--Descriptive Statistic by Gender

Gender	Mean	N	SD	Median	Grouped Median
male	4.2	18	3.4	3.4	3.4
female	2.4	17	3.2	0.8	0.8
Total	3.3	35	3.4	2.5	2.5

Figure D.10 shows all exhibits in the tracking-and-timing study, in rank order by mean, with the standard error of the means for the distribution, and the 95% confidence intervals for the upper and lower limits of the true mean. If the upper and lower confidence intervals do not overlap, 95% of the time the true means of a sample this size will be different. If they do overlap, the distributions are not considered to be significantly different. While most APE means are



significantly different from most non-APE means, neither the mean of *Downhill Race* nor *Ice Painting* can be said to be different from the means of *Touch the Spring* or *Liquid Litmus*.

Figure D.10: Time Rank Order by Mean

Type	Exhibit	N	Mean	Std. Error of Mean	Upper Confidence Interval	Lower Confidence Interval
APE	<i>Circuit Workbench</i>	34	3.42	0.58	4.00	2.83
APE	<i>Floating Objects</i>	49	1.98	0.25	2.23	1.73
APE	<i>Downhill Race</i>	51	1.69	0.22	1.91	1.47
APE	<i>Ice Painting</i>	26	1.42	0.24	1.66	1.18
non-APE	<i>Touch the Spring</i>	33	1.39	0.13	1.52	1.25
non-APE	<i>Liquid Litmus</i>	26	1.28	0.18	1.47	1.10
non-APE	<i>Bubble Suspension</i>	36	0.89	0.11	1.00	0.78
non-APE	<i>Rift Zone</i>	60	0.85	0.11	0.95	0.74
non-APE	<i>Water Standing on Air</i>	34	0.74	0.09	0.84	0.65
non-APE	<i>Circling Waves</i>	29	0.57	0.11	0.67	0.46



APPENDIX E: DESCRIPTION OF RESPONDENTS – OBSERVATIONS/INTERVIEWS

Figure E.1: Description of Social Groups, Observational Data

Type	Exhibit Name	Respondent Number	Debrief Social Group Description	Minutes at Exhibit	Interview
Non-APE	<i>Bubble Suspension</i>	APE2_030805AK_01	Man and woman, 20s, couple. 4-year-old boy. White, looked like they were from out of town.	2	No
APE	<i>Downhill Race</i>	APE2_030805AK_02	White m/f couple, about 60, well-to-do-looking, visiting from Texas for business.	4	Yes
Non-APE	<i>Touch the Spring</i>	APE2_030805CT_01	Man, about 50. He was alone at this exhibit. I later found out that he was at the Exploratorium with his grandson, but he was alone during his time using this exhibit.	1	Yes
APE	<i>Downhill Race</i>	APE2_030805CT_2	Boy 12. I thought he was with two other children, but then realized that they had on camp shirts. He was working with them and talking to them, but they left before he did. In the interview I found out that he was visiting the Exploratorium with his parents and a younger brother. He was using the exhibit away from his family but interacting with other young visitors.	17	Yes
Non-APE	<i>Touch the Spring</i>	APE2_030805JG_01	Caucasian boy, about 10 years old. Caucasian woman, looking like she was in her late 30s, early 40s. Second Caucasian woman, in her 40s.	1	No
Non-APE	<i>Bubble Suspension</i>	APE2_030805JR_01	The young girl, age 6, was using the exhibit and was then joined by her mother. Her older brother, 10, was in the group but I did not observe him engaging with this particular exhibit.	2	Yes



Type	Exhibit Name	Respondent Number	Debrief Social Group Description	Minutes at Exhibit	Interview
APE	<i>Downhill Race</i>	APE2_030805JR_02	Female, Caucasian, late 40s; female, Caucasian, around 6 years old.	2	Yes
Non-APE	<i>Bubble Suspension</i>	APE2_030805MK_01	2 older adults (who, as it turns out, are the grandparents) of 2 kids, approximately 8 and 10. The kids are visiting the Bay Area (where the G-parents live) for a week from Colorado. They are spending the week going around doing fun activities.	4	Yes
APE	<i>Circuit Workbench</i>	APE2_030805MK_02	I believe that this was a married couple. By the time I actually talked with them, I don't think they had any children with them, though I thought they did at first.	1.5	No
Non-APE	<i>Bubble Suspension</i>	APE2_030805SB_01	Single visitor, woman, ~50, white, middle class? Used exhibit alone, says during interview her husband and 3 kids (15, 17, 19 yrs) are elsewhere.	10	Yes
APE	<i>Circuit Workbench</i>	APE2_030805SB_02	Woman, 25-30 yrs, boy 8 yrs. (estimated – missing front tooth), Hispanic, first time to Exploratorium.	6	Yes
APE	<i>Circuit Workbench</i>	APE2_030806CT_01	Girl who I thought was older but turned out to be 12, 7th grade. She was in a family group with her mom, a little boy about 3 or 4 and a baby in a stroller. They waited nearby as she used the exhibit.	2	Yes
APE	<i>Downhill Race</i>	APE2_030806CT_02	This was an African-American group with 5 children. 3 little girls (under 5), an older girl, about 7, and a boy about 9 or 10. I was never able to determine if they were a family group or if there were additional children with nuclear family.	1	No



Type	Exhibit Name	Respondent Number	Debrief Social Group Description	Minutes at Exhibit	Interview
APE	<i>Ice Painting</i>	APE2_030806CT_03	4 people--a white male about 35, a white female of a similar age, a little girl who I learned was 6 and a little boy who I learned had just turned 3 years old.	2	Yes
Non-APE	<i>Water Standing on Air</i>	APE2_030806CT_04	When I originally saw this man, about 45, and girl who I originally thought was about 13 or 14 but turned out to be 9, they were watching an Asian mother and son use this exhibit. Later, at the end of the interview I found the full group included a younger sister, a younger brother, mom, dad, and the girl I interviewed.	2	Yes
Non-APE	<i>Water Standing on Air</i>	APE2_030806JR_01	Adult male, Caucasian, 40s accompanied by 3 children ranging in age from <1 to 5, also adult female in group, Caucasian, 40s.	1	No
Non-APE	<i>Water Standing on Air</i>	APE2_030806JR_02	Male, Caucasian, young adult, around 20; female, Caucasian, young adult, around 20.	1	Yes
APE	<i>Ice Painting</i>	APE2_030806JR_03	Female adult, race unknown, EST, 40, male child, 11, Caucasian?	3	No
APE	<i>Circuit Workbench</i>	APE2_030806JR_04	Male adult, race unknown, around 38; male child, race unknown, possibly Filipino, around 12.	3	Yes
APE	<i>Ice Painting</i>	APE2_030806JR_05	Male teen, African-American, about 15; female teen, African-American, about 15; they were part of a larger group	6	Yes



Type	Exhibit Name	Respondent Number	Debrief Social Group Description	Minutes at Exhibit	Interview
Non-APE	<i>Touch the Spring</i>	APE2_030806SB_01	4 girls, 2 boys, teenagers (about 17 yrs) I didn't know the complete size of the group, until they all sat down with me for the interview. At the exhibit, I observed 2 girls and 1 boy, who mixed as part of the crowd at the exhibit. The surrounding crowd using the exhibit consisted of 2 young (~8 yrs) boys, and the remaining 3 members of the group. . They said they were from Spain and were in San Francisco for a month.	13	Yes
APE	<i>Downhill Race</i>	APE2_030806SB_02	Mother, 2 girls and 2 boys, the girls 15 and 13, the boys 8 and 6? Asian family, I interview the 2 girls and the older boy. Mom hangs nearby, but doesn't talk.	8	Yes
APE	<i>Ice Painting</i>	APE2_030806SB_03	Male, white, ~40 yrs old; girl, ~7.	1	No
APE	<i>Ice Painting</i>	APE2_030806SB_04	Woman and man, young 20s, white, he has dreadlocked hair.	2	No
Non-APE	<i>Bubble Suspension</i>	APE2_030806SB_05	Three teen girls, 15 yrs old, Asian.	1	Yes
Non-APE	<i>Touch the Spring</i>	APE2_030807AK_01	Single male, white, mid-30s. UNIX systems administrator.	1	Yes
APE	<i>Ice Painting</i>	APE2_030807AK_2	Family group, white, Southern accents, looked like tourists. Man/woman in late 30s, girl 5, girl 7.	11	No
APE	<i>Circuit Workbench</i>	APE2_030807CT_01	Father (about 45 with son and daughter about 12 or 13).	4	Yes
APE	<i>Ice Painting</i>	APE2_030807CT_02	The young man I watch approach the exhibit was 14 -- this and other ages from the interview. There was a mom and dad in their 40s and I am guessing 2 10-year-olds.	4	Yes



Type	Exhibit Name	Respondent Number	Debrief Social Group Description	Minutes at Exhibit	Interview
APE	<i>Downhill Race</i>	APE2_030807CT_03	Group was a family: dad, mom and 2 little girls. 1 little girl was about 3, and she is included in the observation. The other little girl must have been nearby, but I did not see her until I requested the interview. She was maybe 5 or 6 years old.	2	No
APE	<i>Circuit Workbench</i>	APE2_030807JR_01	Female, Caucasian, 40; male, Caucasian, 4; male Caucasian, [CHECK AGE, FINISH?].	4	Yes
APE	<i>Circuit Workbench</i>	APE2_030807JR_02	Male, Caucasian, early 20s; part of a large group that wandered in and out, the group appeared to be mostly Latinos and Native Americans.	6	Yes
APE	<i>Circuit Workbench</i>	APE2_030808AK_1	Man in his mid 40s, boy about 11 years old. Both white. Father and son. Here on vacation from Long Beach, CA. Father been here before, first time for boy, although he's been to other science centers before. Father is a robot salesman for industry, used to be an electrician.	17	Yes
APE	<i>Downhill Race</i>	APE2_030808AK_02	Man, early 30s, boy about 12 years old. Boy is the son of man's friend. Man local, boy visiting from Chicago.	3	Yes
APE	<i>Circuit Workbench</i>	APE2_030808SB_02	Man and woman, about 45, white; teen boy; teen girl.	5	No
APE	<i>Ice Painting</i>	APE2_030808SB_03	Couple, man and woman, white, mid-20s.	5	Yes
APE	<i>Circuit Workbench</i>	APE2_030808SB_04	Single visitor; boy 13 years old, white.	23	Yes
APE	<i>Ice Painting</i>	APE2_030809MK_01	2 parents in their 40s and 3 teenagers. Only the parents were involved in the interview, however.	10	Yes



Type	Exhibit Name	Respondent Number	Debrief Social Group Description	Minutes at Exhibit	Interview
APE	<i>Ice Painting</i>	APE2_030809MK_02	Grandmother, grandfather (as it turns out, a stepfather to the daughter), 45-year-old daughter, and 7-year-old granddaughter. They live near Auburn now, but were born and raised in Marin. The daughter hadn't been to Explo since she was 15, and the first time she came she was 7. Her daughter had come a couple of weeks ago with the grandparents and a niece, and had a great time, which is why they came again.	6.5	Yes
APE	<i>Circuit Workbench</i>	APE2_030809MK_03	Grandmother (GM) and Granddaughter (GD), about 10. GM lives in Fairfield, and GD visiting from Nevada, both have British accent, but somewhat subtle. Just drove over to visit for the day.	8	Yes
APE	<i>Downhill Race</i>	APE2_030809SB_01	Boy, about 13, and grandmother, both have slight European [WHAT?].	10	Yes
Non-APE	<i>Water Standing on Air</i>	APE2_030809SB_02	Man and woman, couple, mid-20s, white.	1	Yes
APE	<i>Ice Painting</i>	APE2_030810JR_01	2 female teens, Caucasian, around 13; one male adult, Caucasian, around 45; one female adult, Caucasian, around 45.	3	Yes
APE	<i>Ice Painting</i>	APE2_030810JR_02	1 male, Caucasian, late 30s; one female, Caucasian, late 30s.	4	Yes
APE	<i>Circuit Workbench</i>	APE2_030810MK_01_db.tx	Mom and daughter, around 7 or 8. Asian, with some accent, but not too much of a language barrier.	6	Yes



Type	Exhibit Name	Respondent Number	Debrief Social Group Description	Minutes at Exhibit	Interview
APE	<i>Circuit Workbench</i>	APE2_030810MK_02	A young couple visiting from Germany. The male contributed most of the interview, his English was very good, almost accent-free. The female was quieter, and had more of an accent. I had thought they were with some other people, but in the interview, it turns out that they were just friendly. The male had been to Explo two years ago and really liked it, so came back. They also mentioned the Citipass.	missing	Yes



APPENDIX F: DEFINITION OF ENGAGEMENT CATEGORIES

Data Sets Presented by Time Category

Observation data sets are shown in Figure F.1 coded by engagement time categories. As explained in the methodology section, respondents were selected by purposive sampling, and these times are not intended to be representative of the total visiting population. Rather, they provide cases for comparison. Exhibit name is shown in the left column. Time categories for each observation are shown in the right column. APE exhibit observations are shaded and non-APE observations are shown in white to provide a visual comparison of engagement at the two types of exhibits.

Category	Definition
5=Very Extended	>8 minutes to 23 minutes
4=Extended	>5 to 8 minutes
3=Substantial	>3 to 5 minutes
2=Brief	>1 to 3 minutes
1=Very Brief	1 minute and under

Figure F.1: Observations Coded by Time Category

Exhibit Name	Data Set	Minutes	Time Category
<i>Circuit Workbench</i>	APE2_030808SB_04	23	Very Extended
<i>Circuit Workbench</i>	APE2030808ak_01	17	Very Extended
<i>Downhill Race</i>	APE2_030805ct_02	17	Very Extended
<i>Touch the Spring</i>	APE2_030806SB_01	13	Very Extended
<i>Ice Painting</i>	APE2_030807ak_02	11	Very Extended
<i>Bubble Suspension</i>	APE2_030805SB_01	10	Very Extended
<i>Downhill Race</i>	APE2_030809SB_01	10	Very Extended
<i>Ice Painting</i>	APE2_030809MK_01	10	Very Extended
<i>Circuit Workbench</i>	APE2_030809MK_03	8	Extended
<i>Downhill Race</i>	APE2_030806SB_02	8	Extended
<i>Ice Painting</i>	APE2_030809MK_02	6.5	Extended
<i>Circuit Workbench</i>	APE2_030805SB_02	6	Extended
<i>Circuit Workbench</i>	APE2_030807jr_02	6	Extended
<i>Circuit Workbench</i>	APE2_030810MK_01	6	Extended
<i>Ice Painting</i>	APE2_030806jr_05	6	Extended
<i>Circuit Workbench</i>	APE2_030808SB_02	5	Extended
<i>Ice Painting</i>	APE2_030808SB_03	5	Extended
<i>Bubble Suspension</i>	APE2_030805MK_01	4	Substantial
<i>Circuit Workbench</i>	APE2_030897ct_01	4	Substantial
<i>Circuit Workbench</i>	APE2_030807JR_01	4	Substantial
<i>Downhill Race</i>	APE2_030805ak_02	4	Substantial
<i>Ice Painting</i>	APE2_030807ct_02	4	Substantial
<i>Ice Painting</i>	APE2_030810jr_02	4	Substantial



Exhibit Name	Data Set	Minutes	Time Category
<i>Circuit Workbench</i>	APE2_030806jr_04	3	Substantial
<i>Downhill Race</i>	APE2_030808ak_02	3	Substantial
<i>Ice Painting</i>	APE2_030806jr_03	3	Substantial
<i>Ice Painting</i>	APE2_030810jr_01	3	Substantial
<i>Bubble Suspension</i>	APE2_030805JR_01	2	Brief
<i>Bubble Suspension</i>	APE2_030805JR_01	2	Brief
<i>Bubble Suspension</i>	APE2_030805ak_01	2	Brief
<i>Circuit Workbench</i>	APE2_030806ct_01	2	Brief
<i>Downhill Race</i>	APE2_030805JR_02	2	Brief
<i>Downhill Race</i>	APE2_030807ct_03	2	Brief
<i>Ice Painting</i>	APE2_030806ct_2	2	Brief
<i>Ice Painting</i>	APE2_030806SB_04	2	Brief
<i>Water Standing on Air</i>	APE2_030806ct_04	2	Brief
<i>Circuit Workbench</i>	APE2_030805MK_02	1.5	Brief
<i>Bubble Suspension</i>	APE2_030806SB_05	1	Very Brief
<i>Downhill Race</i>	APE2_030806ct_02	1	Very Brief
<i>Ice Painting</i>	APE2_030806SB_03	1	Very Brief
<i>Touch the Spring</i>	APE2_030805JG_01	1	Very Brief
<i>Touch the Spring</i>	APE2_030805CT_01	1	Very Brief
<i>Touch the Spring</i>	APE2_030807ak_01	1	Very Brief
<i>Water Standing on Air</i>	APE2_030806jr_01	1	Very Brief
<i>Water Standing on Air</i>	APE2_030806JR_02	1	Very Brief
<i>Water Standing on Air</i>	APE2_030809SB_02	1	Very Brief
<i>Circuit Workbench</i>	APE2_030810MK_02	missing	0



APPENDIX G: PERCENTAGE OF VISITORS AT EXHIBITS BY ENGAGEMENT CATEGORY

Time at Exhibit by Engagement Category

Category	Definition
5=Very Extended	>8 minutes to 23 minutes
4=Extended	>5 to 8 minutes
3=Substantial	>3 to 5 minutes
2=Brief	>1 to 3 minutes
1=Very Brief	1 minute and under

Figure G.1: Tracking-and-timing Exhibits by Time Categories

Exhibit Type	Exhibit Name	Very Brief	Brief	Substantial	Extended	Very Extended	Total
APE	<i>Circuit Workbench</i>	32.4	35.3	11.8	11.8	8.8	100.0
	<i>Downhill Race</i>	41.2	52.9	2.0	3.9	0.0	100.0
	<i>Floating Objects</i>	46.9	36.7	10.2	6.1	0.0	100.0
	<i>Ice Painting</i>	50.0	46.2	3.8	0.0	0.0	100.0
non-APE	<i>Bubble Suspension</i>	63.9	36.1	0.0	0.0	0.0	100.0
	<i>Circling Waves</i>	82.8	17.2	0.0	0.0	0.0	100.0
	<i>Liquid Litmus</i>	50.0	50.0	0.0	0.0	0.0	100.0
	<i>Touch the Spring</i>	31.3	68.8	0.0	0.0	0.0	100.0
	<i>Rift Zone</i>	68.3	30.0	1.7	0.0	0.0	100.0
	<i>Water Standing</i>	79.4	20.6	0.0	0.0	0.0	100.0

