# Interactive Exhibits at the Lawrence Hall of Science as a Tool for Environmental Education

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## ABSTRACT

Environmental issues remain critical concerns for our planet, and increasing environmental awareness and knowledge is crucial to motivate the public towards sustainable solutions. Informal learning environments, such as interactive science museums, have the potential to play a critical role in this process by providing visitors with immersive and engaging experiences that help them comprehend environmental concepts and their relevance in daily life. In this study, I investigated the effectiveness of 5 environmentally-driven exhibits at the Lawrence Hall of Science in Berkeley, CA, in educating visitors on relevant environmental topics. Through interviews, exhibit assessments, and visitor observations, I found that exhibits that incorporated real-world examples and contextual learning experiences had higher levels of visitor engagement and better learning outcomes. My findings also highlighted the importance of exhibit accessibility and strategic placement in promoting visitor engagement. These findings have significant implications for exhibit designers and museum curators, emphasizing the need for user-centered design, clear and concise displays, and accessible and engaging exhibits that cater to diverse audiences. Furthermore, my research highlights the role of informal learning environments, such as museums, in enhancing environmental education and awareness. My findings provide valuable insights into the design and evaluation of interactive exhibits for environmental education, reinforcing the need for continued efforts to increase environmental literacy among the public. By understanding the best practices for designing engaging and informative exhibits, interactive exhibits can play a crucial role in promoting environmental awareness and motivating the public to take action toward sustainable solutions.

## KEYWORDS

environmental awareness, interactive exhibits, visitor engagement, science museums, informal learning

## INTRODUCTION

Environmental awareness is a crucial element in educating future generations and promoting ecological responsiveness (Aindrila, 2020). Through teaching pertinent topics such as climate change, conservation, and sustainable practices, young individuals can develop a deep sense of care and concern for the environment. In turn, by becoming environmentally aware, individuals become more conscious of the natural world and how humans impact the environment. Increased environmental awareness will enable future generations to make informed decisions that consider the health of the planet, create a more sustainable future, and protect the Earth for generations to come (Boyes & Stanisstreet, 1993).

Informal learning environments have demonstrated their effectiveness in complementing formal education (Adams, 2021). These learning environments can manifest through day-to-day activities, social interactions, and experiential learning opportunities, and are capable of instilling critical thinking, problem-solving, and creativity while promoting an enduring enthusiasm for learning (Allen 2004). Interactive science museums are an excellent example of such environments, offering an engaging and hands-on way for young minds to become familiar with topics related to the environment. STEM-based exhibits can become a mechanism by which topics of environmental awareness and literacy are transmitted to young learners (Bell and Clover, 2017). Science museums play an important role in encouraging children to pursue STEM in educational institutions and become more environmentally knowledgeable.

While research suggests that interactive exhibits can be effective tools for promoting STEM education in general, little is known about how interactive exhibits can specifically be used to teach visitors about environmental topics (Bell and Clover, 2017). In a review of the literature, Ramey-Gassert et al. (1994) found that informal, hands-on learning environments in museums can enhance science education, but there is a lack of research on how this applies to environmental education specifically. While some studies have evaluated the impact of science museums on visitors' environmental attitudes and behaviors (Kisiel et al., 2012), there is a need for more research on the specific mechanisms by which interactive exhibits can promote environmental awareness and literacy.

My research asks the overarching question: How do the exhibits at the Lawrence Hall of Science educate visitors about relevant environmental topics? Specifically, I will examine how each exhibit communicates the environmental topic, how many of the 9 EDGE Design Attributes each exhibit contains, and how visitors interact with the exhibits.

**Study site**

My research takes place at The Lawrence Hall of Science (LHS), which according to their website, is an institution dedicated to promoting scientific inquiry and providing equitable learning experiences. Founded in 1968 by the University of California Regents to honor Nobel laureate physicist E. O. Lawrence, LHS has been at the forefront of advancing science education for over 50 years (The Lawrence Hall of Science). Aligned with the University of California, Berkeley, LHS collaborates with scientists, engineers, and educators to create optimal learning experiences that leverage diverse perspectives and innovative approaches, driving innovation and transformation in the STEM fields. With a strong commitment to equity and access to STEM education for all individuals, LHS is an ideal location for investigating the effectiveness of interactive exhibits in promoting environmental awareness and education among diverse audiences. LHS has created hundreds of original exhibits spread over 56,000 square feet of public exhibition space (The Lawrence Hall of Science). These exhibits are facilitated by a team of 70 adult instructors, around 90 teen interns, and numerous UC Berkeley students, who conduct on-floor demonstrations for the quarter million visitors who come each year. Moreover, LHS serves as an important outreach effort for the university to extend opportunities to students from all economic backgrounds, providing science faculty with a place to work in K-12 education. With its commitment to promoting scientific inquiry and equitable learning experiences, LHS continues to play a pivotal role in advancing science education for all (The Lawrence Hall of Science). My study aims to examine the effectiveness of five environmentally-driven exhibits at LHS, namely "Science on a Sphere," "Forces that Shape the Bay," "Wind Works," "Shake & Rattle," and "Shaping Watersheds." These exhibits were selected based on their focus on environmental topics and their broad appeal to diverse audiences. The chosen exhibits offer a unique opportunity to investigate how science museum exhibits can promote environmental education and raise awareness among visitors from different backgrounds.

*Selected exhibits*

The first exhibit, Science on a Sphere, is a captivating visual experience that features a 3D video projection of the Earth, displaying a variety of visual effects such as weather patterns, climate change models, and other scientific data collected by the National Oceanic and Atmospheric Administration (NOAA). This impressive exhibit is designed to educate visitors on the complex systems that make up our planet and the impact of human activities on the environment. The exhibit's data-driven visualizations offer an immersive experience that engages visitors and helps them better understand the workings of our planet. By highlighting the effects of human activity on the environment, this exhibit has the potential to push visitors to become more environmentally conscious and make sustainable choices in their daily lives.

Forces that Shape the Bay is an interactive, outdoor science park. This exhibit provides visitors the opportunity to learn about the various geologic forces that have worked together to shape the Bay Area landscape over time. Through engaging activities and simulations, visitors can learn how water erosion, earthquakes, weather, and other geologic forces have contributed to the formation of the region's natural features, including mountains, hills, and valleys. The exhibit is designed to be hands-on and interactive, allowing visitors to experience these forces firsthand and gain a deeper understanding of the natural processes that have shaped the Bay Area.

The Wind Works exhibit is an interactive engineering design challenge that allows visitors to design, build, and test wind turbines. The exhibit aims to educate individuals on the concept of renewable energy and the harnessing of wind power. By experimenting with a variety of blade designs, visitors can gain hands-on experience that allows them to apply their engineering skills in a practical setting and discover effective ways to generate electricity. As visitors experiment with different blade designs, they can learn about the factors that affect the performance of wind turbines and the importance of considering these factors in real-world applications. By engaging in this exhibit, visitors develop an understanding of renewable energy and how it can be utilized to address environmental challenges.

At the Shake & Rattle exhibit, visitors can participate in a hands-on engineering challenge to design and build earthquake-safe structures. This exhibit offers an interactive learning experience that combines science, technology, engineering, and mathematics (STEM) principles to teach visitors about the dangers of earthquakes and how engineers work to mitigate their impact.

Visitors are given the task of designing and building structures that can withstand a simulated earthquake. They test their structures on a shake table, which mimics the vibrations of an earthquake. This exhibit not only teaches visitors about engineering and construction but also raises awareness about earthquake safety and the importance of building structures that can withstand natural disasters.

The Shaping Watersheds exhibit is an informative and interactive exhibit that educates visitors on the impact of water on the Bay Area landscape. The exhibit features a topographic map of the Bay Area that uses different colors to represent different elevations, allowing visitors to visualize the changes in elevation throughout the area. Additionally, visitors can observe a virtual rain shower that falls on the map, with the water eventually draining into a wetland, pond, or lake. This exhibit allows visitors to gain a deeper understanding of how water shapes the Bay Area landscape and how watersheds work, which is an important aspect of environmental education. By providing a visual and interactive experience, the Shaping Watersheds exhibit engages visitors and promotes awareness of water resource management in the Bay Area.

**The EDGE Project**

My research is partially guided by the findings of the EDGE (Exhibit Design for Girls' Engagement) Project, a research initiative that seeks to understand how museum exhibits can better engage girls in STEM (Dancstep and Sindorf 2016). The project, funded by the National Science Foundation, is a collaboration between researchers, educators, and designers from San Francisco's Exploratorium. The primary goal of this study was to develop a set of design principles, known as the EDGE Design Attributes, that can be used to create museum exhibits that are more engaging and inclusive for girls. The findings winnowed a list of 100 potential design attributes to those most important for engaging girls. After conducting thorough research, a list of 9 design attributes that were highly linked with girls' engagement was generated. These attributes are shown to enhance girls' interest and participation in STEM-related exhibits, without negatively affecting boys' engagement. Interestingly, many of these attributes were found to have a positive correlation with boys' engagement as well.

# METHODS

## Interviews

In order to gain insight into the exhibit design process at LHS and better understand how each exhibit communicates environmental information through visual displays and hands-on features, I conducted semi-structured interviews with 5 members of LHS staff involved in exhibit design. The main goal of these interviews was to obtain valuable information about the general exhibit design process and identify common themes that informed my examination of how each exhibit conveys environmental information. For approximately 1 hour and 45 minutes, we discussed a variety of topics such as how they brainstorm and generate ideas for exhibits, the process behind prototyping and testing an exhibit before it is released, and the different ways in which they balance the educational and entertainment aspects of each exhibit. The chosen method was based on the fact that the design staff was the best source of information on the exhibit creation process, considerations taken during the design, the target audience, exhibit accessibility, visitor prototyping, and other relevant factors.

## Exhibit assessments

I personally evaluated each exhibit to determine the extent to which they followed the 9 EDGE Design Attributes. I spent about 5 minutes analyzing each exhibit's design attributes. Initially, I assessed the exhibit from a distance to determine if it had multiple sides or stations, the capacity to accommodate three or more individuals, visitor preview options, and the presence of an exhibit label with a useful drawing. After ensuring that no one was using the exhibit, I observed the exhibit carefully to obtain a comprehensive overview of the exhibit. Then, I conducted further evaluations up close to answer questions related to the exhibit's image, look and feel, and openness. This method was chosen because it allowed for a systematic evaluation of the exhibits based on a predetermined set of criteria.

**Visitor observations**

To assess how visitors interacted with the exhibits, I conducted observations at 15-minute intervals (see Appendices A-E). This method was chosen because it allowed for a routine and comprehensive evaluation of the visitor's interaction with the exhibits. I visited LHS during the overlapping spring break of Berkeley's local elementary and middle schools, from April 3rd to April 7th, and one exhibit was chosen randomly for observation each day. I followed a visitor observation protocol that involved 15 minutes of observations followed by a 15-minute break. I repeated this process three times for each exhibit, resulting in a total of 45 minutes of observation time for each exhibit. According to Alvesson and Karreman (2000), there is no established optimal duration for visitor observations in scientific research. However, observations should be of sufficient length to capture a range of behaviors and activities, while also avoiding fatigue or boredom, which can negatively impact the quality of the observations.

For this data collection, I created a framework for observing how visitors interacted with the various elements of each exhibit. For example, "Shaping Watersheds" comprised three distinct elements, namely a virtual rain feature, a drain button, and an infographic. Visitors could choose to engage with this exhibit in a variety of ways, ranging from passive observation to active participation by carefully following the instructions and manipulating the virtual rain and drain features. To ensure consistency and accuracy in my observations, I developed a standardized coding system, which enabled me to efficiently document multiple visitor interactions within a brief time frame.

The coding system used a scale ranging from 0 to 3, where 0 indicated no interaction or acknowledgment of the exhibit, 1 indicated a brief look or watch, 2 indicated a brief touch or contact, and 3 indicated interaction. I collected data on the visitor's approximate age and gender, whether they were assisted by a parent or guardian, exhibit elements with codes, approximate interaction time, and overall notes on interactions. The scale used in the coding system provided a clear and straightforward method for categorizing visitor interactions. Assigning a numerical value to each level of interaction made it easier to compare the level of engagement across different exhibits and visitors. By also collecting data on visitor demographics, such as age and gender, I had the ability to identify patterns in exhibit engagement among different visitor groups and use this information to improve exhibit design.

# RESULTS

## Themes from staff interviews

Following a series of interviews with staff members at LHS, several key themes emerged that illuminate the strategies used by the exhibit design team in creating and communicating information to visitors (Table 1). One of the key themes identified during the interviews was centered on the exhibit creation process, which emphasized the significance of ideation and input from various sources, including museum visitors, experts, and stakeholders. The process of prototyping, testing, and refining interactive elements were highlighted as essential, as well as the evaluation of visitor feedback to make necessary changes. Ultimately, exhibits must undergo rigorous testing and preparation before they are ready for public viewing.

Another key theme that emerged from the interviews was the significance of clear, concise, and visually engaging displays in conveying information effectively (Table 1). This theme encompassed two related aspects of exhibit design and effectiveness. Firstly, by creating interactive, meaningful, and intuitive experiences, designers can ensure that visitors gain the intended educational value from the exhibit. Secondly, the design team emphasized that exhibits incorporating such displays were more successful in engaging visitors and communicating relevant environmental issues to them. Additionally, the principles of universal design were prioritized to ensure accessibility and challenge for visitors, regardless of age, ability, or background. Evaluations and feedback were deemed crucial to assess whether the exhibit was meeting the needs and expectations of its target audience.

Lastly, the theme revolving around environmental science in exhibits illustrated how exhibits that delve into topics such as energy conservation, earthquake preparedness, and geological forces can aid visitors in comprehending the natural processes that shape our environment (Table 1). Examples such as "Forces That Shape the Bay" and "Shake & Rattle" were cited as noteworthy instances of this approach.

**Table 1. Main themes derived from interviews.**

| Main Categories | Themes | Sub-themes |
|---|---|---|
| **Creation process** | Idea generation | Brainstorming ideas<br>Concept development |
| | Prototyping and testing | Building prototypes<br>Refining interactive elements |
| | Construction | Testing<br>Visitor readiness and accessibility |
| **Exhibit design and effectiveness** | Educational value | Intuitive experiences<br>Relevance and meaningfulness<br>Clear and engaging |
| | Accessibility | Design for all ages, abilities, and backgrounds |
| **Environmental science in exhibits** | Relevant topics | Geological forces<br>Earthquakes<br>Energy conservation |
| | Benefits | Understanding natural processes<br>Promoting harmony with natural world |

## Exhibit assessments

I analyzed each exhibit according to which EDGE Design Attributes it follows. “Wind Works” and “Science on a Sphere” had the lowest number of attributes at 3 out of 9, “Forces that Shape the Bay” had 5 of 9, “Shake & Rattle” had 6 of 9, and “Shaping Wetlands” had 8 of 9 (Table 2).

**Table 2. Exhibits' respective EDGE Design Attributes.**

| Exhibit Title | EDGE Design Attributes |
|---|---|
| **Forces that Shape the Bay** | Playful, whimsical, or humorous<br>Multiple sides/stations<br>Space to accommodate 3+<br>Visitors can watch others to preview<br>Open-ended |
| **Wind Works** | Space to accommodate 3+<br>Visitors can watch others to preview<br>Open-ended |
| **Shake & Rattle** | Use drawing<br>Image of a person<br>Homey, personal, homemade, or delicate<br>Multiple sides/stations<br>Space to accommodate 3+<br>Visitors can watch others to preview<br>Open-ended |
| **Science on a Sphere** | Space to accommodate 3+<br>Visitors can watch others to preview<br>Open-ended |
| **Shaping Watersheds** | Use drawing<br>Image of a person<br>Homey, personal, homemade, or delicate<br>Playful, whimsical, or humorous<br>Multiple sides/stations<br>Space to accommodate 3+<br>Visitors can watch others to preview<br>Open-ended |

Table 3 presents the summarized findings of my visitor observations, which each occurred in a total of 45 minute observation periods. "Total Observations" represents the total count of visitors observed at each exhibit, while "Observations with Interactions" indicates the number of visitors who fully interacted with the exhibit rather than simply observing or making brief contact. Exhibits with the lowest number of total observations, namely "Forces that Shape the Bay" and "Shaping Watersheds," were also the exhibits where visitors spent the least amount of time, averaging under one minute. On the other hand, "Shake and Rattle" garnered the highest number of total observations with a count of 11, and visitors spent an average of approximately 3.5 minutes at this exhibit. Similarly, visitors spent an average of 3 minutes at "Wind Works," despite receiving fewer observations than "Shake and Rattle." In contrast, "Science on a Sphere" received a higher count of observations, but visitors spent less time at this exhibit on average, approximately 1.5 minutes.

**Table 3. Summary of visitor observation data.**

| Exhibit Title | Total Observations | Observations with Interaction | Average Time Spent at Exhibit (min) | Average Age (estimate) | # Male | # Female |
|---|---|---|---|---|---|---|
| **Forces that Shape the Bay** | 5 | 0 | <1 | 6 | 3 | 2 |
| **Wind Works** | 6 | 4 | 3 | 7 | 3 | 3 |
| **Shake & Rattle** | 11 | 10 | 3.5 | 10 | 7 | 4 |
| **Science on a Sphere** | 9 | 5 | 1.5 | 9 | 4 | 5 |
| **Shaping Watersheds** | 4 | 0 | <1 | 7 | 2 | 2 |

## DISCUSSION

My research objective was to determine how exhibits at the Lawrence Hall of Science (LHS) educate visitors about relevant environmental topics. I used semi-structured interviews with 5 members of the exhibit design team at LHS, assessed environmentally-driven exhibits, and recorded visitor observations at each of the 5 selected exhibits. My findings suggest that exhibits that are engaging tend to have longer interaction times, highlighting the importance of sustaining engagement throughout the entire interaction. Moreover, my research emphasizes the significance of environmental education in exhibits and recommends that exhibit designers consider how to incorporate real-world examples and contextual learning experiences into their designs to enhance visitor engagement and learning outcomes.

### Engagement and real-world examples

Visitor engagement is a critical factor in the success of museum exhibits (Griffin 1998). My research found that exhibits that are more engaging tend to have longer interaction times. This highlights the importance of exhibits not only grabbing visitors' attention but also captivating their interest and maintaining their attention to achieve the desired educational outcomes. One effective way to achieve this is through the use of real-world examples and contextual learning experiences. The study found that the exhibit "Shake & Rattle" was particularly effective in conveying the importance of earthquake preparedness and geological forces to visitors. These results align with previous studies that have highlighted the value of incorporating real-world examples and contextual learning experiences in exhibits to improve visitor engagement and learning outcomes (Mortensen 2011). Ultimately, the findings of this section emphasize the significance of environmental science education in exhibits and suggest that exhibit designers should consider how to incorporate real-world examples and contextual learning experiences into their designs to enhance visitor engagement and learning outcomes. Exhibits should be designed to not only attract visitors but also sustain their engagement and effectively communicate relevant environmental issues to them.

### Exhibit design process

Several key themes emerged during the interviews with staff members that shed light on the exhibit design process, such as ideation, input from various sources, prototyping, testing, and refining interactive elements. These findings are in line with similar studies that highlight the importance of collaboration and user-centered design in exhibit development (Hirumi et al. 1994). One of the key themes that emerged from the interviews was the significance of clear, concise, and visually engaging displays in conveying information effectively. The design team emphasized that exhibits incorporating such displays were more successful in engaging visitors and communicating relevant environmental issues to them. For example, “Shake & Rattle” was highly effective in grabbing the attention of visitors and sustaining their engagement, which is demonstrated through a total of 10 interactions and a 3.5-minute average observation time. This finding is supported by previous research that has shown that exhibits with interactive and visually appealing displays can increase visitor engagement and learning outcomes (Kember et al. 2010). Moreover, the principles of universal design were prioritized to ensure accessibility and challenge for visitors, regardless of age, ability, or background. This is consistent with previous studies that have highlighted the importance of accessibility in exhibit design (Story 1998).

**Importance of exhibit accessibility and location**

Exhibit accessibility and location are crucial aspects of designing exhibits that encourage visitor engagement. The placement of exhibits can significantly impact visitor interactions, with exhibits located in less accessible areas often exhibiting lower engagement levels. For instance, the exhibit boasting the highest number of EDGE Design Attributes, “Shaping Watersheds,” paradoxically exhibited the lowest level of engagement. the exhibit was positioned in a secluded and obscure location in the farthest corner of the room, making it virtually invisible to the majority of visitors. A well-placed exhibit can capture the attention of visitors and draw them in, while a poorly located exhibit may be overlooked entirely (Van Schundel et al. 2010). This means that museum designers and curators must carefully consider the placement of each exhibit to ensure that it is easily accessible and visible to visitors, maximizing its potential to educate and engage the public.

**Limitations**

My study possesses a number of limitations that warrant attention. Firstly, my research was conducted at a single science center, and as such, the results may not be generalizable to other science centers or museums. Additionally, the study only assessed a limited number of exhibits, which may limit the extent to which the findings can be extrapolated to other exhibits within the same science center or in other museums. Furthermore, while the interviews conducted with reliable LHS staff provided valuable insights into the effectiveness of the exhibits, the relatively small sample size may limit the representativeness of the findings. The small sample size also restricts the ability to make definitive conclusions about the efficacy of the exhibits in educating visitors. While the results of this study offer valuable contributions to the design and evaluation of museum exhibits for environmental science education, further research is necessary to address these limitations and extend the findings. Future studies could examine additional science centers, assess a greater number of exhibits, and conduct interviews with a larger and more diverse sample of visitors to obtain a more comprehensive understanding of the effectiveness of exhibits in promoting environmental literacy.

**Future directions and research priorities**

Based on the limitations identified in this study, there are several future directions that could be pursued to build upon these findings. One potential avenue for future research is to incorporate surveys into the data collection process. This would allow for a more comprehensive understanding of visitors' learning outcomes and could provide insight into what, specifically, they are taking away from the exhibits. In addition, replication may be needed as these findings are based on the perspectives and observations of one primary researcher. Finally, future studies could benefit from the use of recorded and transcribed interviews, which would provide a more in-depth analysis of the data and allow for a better understanding of visitors' experiences and perceptions of the exhibits. These future directions could contribute to a more comprehensive understanding of the effectiveness of environmentally-driven exhibits in informal learning environments, and provide insight into how to design exhibits that better engage visitors and promote environmental literacy.

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# APPENDIX A

| Person # | M/F/? | Approx. Age | Help (?) | Erosion Table | Telescope | Water Flow | Total Interaction Time (min) | Notes | Key |
|---|---|---|---|---|---|---|---|---|---|
| 1 | M | 8 | Y | 0 | 0 | 1<br>< 1 min | <1 min | ***windy conditions***<br>1:<br>- walked outside with parent/guardian (F)<br>- looked at water flow exhibit for a moment & ran back inside<br><br>2 & 3:<br>- 2 boys, approx. 5 & 7, with M & F parents/guardians<br>- ran to water flow simulation & played with water for less than<br>1 minute before coming back inside<br><br>4:<br>- 1 girl, accompanied by M parent/guardian<br>- observed water flow simulation for <1 min, pointed in water,<br>& went back inside | **Key**<br><br>**0 = Nothing**<br>**1 = Quick look/watch**<br>**2 = Quick Touch/Contact**<br>**3 = Interaction** |
| 2 | M | 5 | Y | 0 | 0 | 2<br>< 1 min | <1 min | | |
| 3 | M | 7 | Y | 0 | 0 | 2<br>< 1 min | <1 min | | |
| 4 | F | 6 | Y | 0 | 0 | 1<br>< 1 min | <1 min | | |
| 5 | F | 6 | Y | 0 | 0 | 1<br>< 1 min | <1 min | | |

Forces that Shape the Bay raw visitor observation data.

# APPENDIX B

| Person # | M/F/? | Approx. Age | Help (?) | Blade | Button | Total Interaction Time (min) | Notes |
|---|---|---|---|---|---|---|---|
| 1 | M | 8 | Y (M/F p/g) | 0 | 2 | <1 min | 1:<br>- walked up to exhibit with 2 parents/guardians, was encouraged to make contact<br>- left exhibit without interacting<br><br>2:<br>- approached exhibit with male parent/guardian help<br>- remained engaged with blade design & left exhibit<br><br>3:<br>- spent interaction time testing and re-testing blade designs<br><br>4:<br>- approached exhibit with help from female parent/guardian<br>- p/g assisted with the button mechanism for approx. 1 min<br><br>5 & 6:<br>- 2 girls ran up to exhibit with parents/guardians<br>- younger girl watched older girl for a couple minutes while she experimented with different blade designs<br>- older sister interacted with blades, but did not redesign<br>- 2 parents/guardians (M & F), F w/ younger visitor & M checking phone |
| 2 | M | 10 | Y (M p/g) | 3 ~2 min | 3 | ~4 min | |
| 3 | F | 8 | Y (M/F p/g) | 3 | 3 | ~5 min | |
| 4 | M | 5 | Y (F p/g) | 0 | 3 | ~1 min | |
| 5 | F | 4 | Y (M/F p/g) | 1 ~2 min 2 | 0 | ~3 min | |
| 6 | F | 6 | Y (M/F p/g) | 3 ~2 min | 3 | ~4 min | |

**Key**

0 = Nothing
1 = Quick look/watch
2 = Quick Touch/Contact
3 = Interaction

Wind Works raw visitor observation data.

# APPENDIX C

| Person # | M/F/? | Approx. Age | Help (?) | Build | Test | Re-Design | Total Interaction Time (min) |
|---|---|---|---|---|---|---|---|
| 1 | M | 10 | Y (F p/g) | 3 | 3 | 0 | ~6 min |
| 2 | F | 5 | Y (F p/g) | 1 -> 2 | 0 | 0 | ~1 min |
| 3 | F | 10 | N | 3 | 3 | 3 | ~5 min |
| 4 | M | 12 | N | 3 | 3 | 0 | ~4 min |
| 5 | M | 10 | Y | 3 | 3 | 3 | ~4 min |
| 6 | M | 8 | Y | 0 | 3 | 0 | ~1 min |
| 7 | F | 12 | N | 3 | 3 | 0 | ~3 min |
| 8 | M | 11 | N | 3 | 3 | 3 | ~3 min |
| 9 | M | 10 | Y | 1 | 3 | 0 | ~2 min |
| 10 | F | 9 | Y | 3 | 3 | 0 | ~4 min |
| 11 | M | 9 | Y | 3 | 3 | 3 | ~3 min |

**Notes**

1:
- constructed earthquake structure after reading directions & watching video, did not re-design

2:
- helped (1) construct building for ~1 min and then ran away - F parent/guardian followed

3:
- 1 girl, approx. 10 years old, approached exhbit right away and watched video on how to build
- built small structure, it didn't collapse, built bigger structure

4:
- approached alone, built structure and tested it multiple times with different shakes, did not re-build

5:
- 1 boy, about 10, approached with parent/guardian
- built structure together and tested briefly, then re-built after structure fell

6:
- 1 boy, about 8, walked up & parent/guardian stood back while they tested different buttons with previous structure

7:
- 1 girl, about 12, cleaned up station and built from scratch
- tested structure, but did not re-build

8:
- 1 boy, about 11, walked up alone
- built tall structure, fell, re-built

9:
- was watching previous visitor (8) with parent/guardian standing beside
- tested structure that was previously built by testing w/ buttons

10:
- 1 girl, about 9, approached with 2 parents/guardians
- built complex, tall structure and watched video
- tested with multiple buttons, did not re-build

11:
- 1 girl, about 9, walked up with parent/guardian & build new structure
- tested with buttons & re-built & tested again

**Key**

0 = Nothing
1 = Quick look/watch
2 = Quick Touch/Contact
3 = Interaction

Shake & Rattle raw visitor observation data.

# APPENDIX D

| Person # | M/F/? | Approx. Age | Help (?) | Tablet | Globe | Total Interaction Time | Notes | Key |
|---|---|---|---|---|---|---|---|---|
| 1 | M | 10 | Y | 3 | 1 | ~3 min | 1 & 2:<br>- Insctructor guided visitors through various models and datasets<br>- Looked at "non-Earth" planets and turtle migration patterns<br>- Girl ran away after ~2 minutes | 0 = Nothing<br>1 = Quick look/watch<br>2 = Quick Touch/Contact<br>3 = Interaction |
| 2 | F | 6 | Y | 3 | 1 | ~2 min | | |
| 3 | F | 8 | Y | 0 | 1 | ~1 min | | |
| 4 | M | 10 | Y | 0 | 1 | ~1 min | 3, 4, & 5:<br>- Next 3 visitors watched instructor demonstration for ~1 min and walked away | |
| 5 | M | 10 | Y | 0 | 1 | ~1 min | | |
| 6 | M | 4 | Y | 3 | 1 | ~2 min | 6:<br>- 1 boy, about 4, walked up with parent/guardian behind and they looked at the tablet together<br>- Explored tablet together and tried different features and settings | |
| 7 | F | 8 | Y | 3 | 1 | ~2 min | 7:<br>- 1 girl, about 8 came up right after and continued lookng at different planets and earthquake data | |
| 8 | F | 12 | N | 3 | 1 | ~2 min | | |
| 9 | F | 6 | Y | 0 | 1 | ~2 min | | |

Science on a Sphere raw visitor observation data.

# APPENDIX E

<table>
<tr><th>Person #</th><th>M/F/?</th><th>Approx. Age</th><th>Help (?)</th><th>Virtual Rain</th><th>Drain Button</th><th>Infographic</th><th>Total Interaction Time (min)</th><th>Notes</th><th>Key<br><br>0 = Nothing<br>1 = Quick look/watch<br>2 = Quick Touch/Contact<br>3 = Interaction</th></tr>
<tr><td>1</td><td>F</td><td>10</td><td>N</td><td>2</td><td>0</td><td>1</td><td><1 min</td><td rowspan="4">1:<br>- used virtual rain element after reading infographic & then walked away<br><br>2:<br>- walked up after watching previous visitor (1) and used rain feature, drained the watershed using the button, and then left<br><br>3 & 4:<br>- walked up together with parent/guardian (on phone), pressed<br>the drain button and then left</td><td rowspan="4"></td></tr>
<tr><td>2</td><td>M</td><td>5</td><td>Y</td><td>1 -> 2</td><td>2</td><td>0</td><td><1 min</td></tr>
<tr><td>3</td><td>M</td><td>7</td><td>Y</td><td>0</td><td>2</td><td>0</td><td><1 min</td></tr>
<tr><td>4</td><td>F</td><td>9</td><td>Y</td><td>0</td><td>2</td><td>0</td><td><1 min</td></tr>
</table>

Shaping Watersheds raw visitor observation data.