INVESTIGATING VISUAL INSTRUCTIONS FOR MECHANICAL EXHIBITS AT THE SCIENCE MUSEUM, LONDON, UK

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P.S. Jin, Germany IS going to win the World Cup.

ABSTRACT

This project explored adding visual labels to two exhibits in the Launch Pad gallery of the London Science Museum. Visual labels are instructional videos or slideshows that demonstrate the proper use of interactive exhibits and tie scientific principles to a visitor's real life. We tested three different visual labels on two exhibits, the Turntable and the Arch Bridge. Through our analysis based on observation and interviews, we identified factors of success and failure across these methods.

EXECUTIVE SUMMARY

The City of London draws more than 11.5 million visitors a year, and is considered one of the most popular tourist attractions overseas[1]. Visitors flock to London for its beauty, history, culture, and the reputation of having many of the best museums in the world. The London Science Museum, located in the museum district in South Kensington, is one of the world's leaders in visitor research, and is constantly working to improve the learning experience of each individual who walks through their doors. One gallery that has drawn the museum staff's attention in recent years is the Launch Pad, which is an interactive gallery designed for children ages 8 – 14. In the Launch Pad children get to experiment with science in new and exciting ways, and get a unique opportunity to "learn by doing". Because the Launch Pad is being moved from its current location in the basement, to the third floor of the museum in 2007, the staff sees this as an opportunity to make necessary improvements to the exhibits currently in the Gallery.

Currently however, the museum is having trouble with the way that visitors interact with some of the exhibits in the Launch Pad. The visitor research department believes that several of the exhibits are being treated like playground equipment and are not providing the educational value that they are capable of. Our project goal was to test the effects of adding video labels to two of these exhibits, to help communicate the purpose of the exhibits more clearly, and to encourage correct interaction. Additionally we also tested the effect of adding a label consisting of a series of static pictures, or a slide show, to one of the exhibits as a possible alternative to video. To accomplish our goal we outlined several objectives that would need to be completed.

1. Test the effectiveness of the current text labels on each target exhibit
2. Design a video label and/or slide show label on each target exhibit
3. Test the effectiveness of the prototype visual label on each target exhibit

The two exhibits that we chose to work with were the Turntable, and the Arch Bridge. (See Figure 1 and Figure 2) The Turntable is a very popular exhibit that was built to demonstrate the principle of conservation of angular momentum. This is a very abstract concept however, and is extremely difficult to illustrate to children ages 8 – 14, especially because they have had absolutely no background in physics at this point in their education. The exhibit works by providing a circular plate for visitors to stand on, with a pole attached to hold on to. The visitor

[1] Office for National Statistics, *National Statistics Online* http://www.statistics.gov.uk/cci/nugget.asp?id=390

is supposed to push off the floor with their feet and spin around. As they spin, the visitor is directed to lean back, and notice how they spin slower than before. By noticing this difference in rotation speed, they are beginning to grasp the basics of angular momentum. However in practice this rarely happened. Typically a visitor would simply spin on the Turntable for a brief period of time, and then step off and walk away.

Figure 1: Turntable Exhibit in Launch Pad Gallery

The other exhibit we tested video labels on was Arch Bridge, which also was not being used successfully according to the visitor research department. The Arch Bridge exhibit is designed to teach children about arches, including how and why they are used in man made structures. Also the exhibit demonstrates the concepts of forces, keystones, bridges, and structures. The visitor is supposed to make an arch shaped bridge over a small gap using 5 identical wooden blocks (stones) that fit together perfectly. Then the visitor is instructed to test their creation by walking over it and seeing how easily it can support their weight. The problem with Arch Bridge is that visitors do not invest enough time into making their own bridge and testing it.

We began by conducting simultaneous visitor observations and interviews for the Turntable exhibit. At the same time we started creating a slide show label and a video label for the exhibit, which we would test to see how variables like interaction time, proper use, and understanding of the exhibits scientific concept would be affected.

We designed the visual labels to be both concise, and informative about the proper use of the Turntable. Each label was designed to be less than 30 seconds, to give visitors the best chance at seeing the important instructions. For the slide show label, we decided to display each slide for 5 seconds. We created a total of 5 slides detailing the proper use of Turntable, creating a loop that lasted 25 seconds in total. The video was created by filming one of the museum's explainer staff using the exhibit successfully, and then short subtitles were added to clarify important points. We chose to use an explainer because they are responsible for showing visitors how to use Launch Pad exhibits, and we believed that the connection would be easy for most

children to make. When creating the video for Turntable, we also included a 10 second clip of an ice skater performing a corkscrew spin, to make a connection between the science of the exhibit and real life situations common to museum visitors.

For the Arch Bridge we only designed a video label, due to time constraints and because our data indicated that video labels were more effective than text labels for several reasons. The video label for Arch Bridge was also kept below 30 seconds. It encouraged visitors to interact with the exhibit more completely by showing the explainer taking down any bridge that was already present, building his own bridge, and then testing it to see how strong the bridge was.

Figure 2: Arch Bridge Exhibit in Launch Pad Gallery

To analyze our data we graphed important variables as percentages, so changing trends could be observed easily. To help ensure the validity of our data we utilized the Chi-Squared statistical test, using a significance level of 0.05, which is a common value for social science studies. This helped us to prove that the changes we observed when the data was analyzed, were not random and were instead caused by the addition of our visual labels.

The analysis of our data for the Turntable yielded some very encouraging results about the success of video labels. The three successful categories that we observed for on the Turntable were “Controlled Speed”, “Leaned In and Out”, and “Started Leaning Back”. We used specific criteria to carefully observe for each one of these behaviors. All three behaviors help to contribute to a successful visitor interaction with Turntable, and the combination of all three was considered a perfect interaction. When graphically analyzed, it shows how each of these observed behaviors noticeably increased when the video label was present at the exhibit. (See Figure 3) One of the most dramatic increases was the “Leaned In and Out” variable, which saw an increase from 16% in the control group to 50% with the video label group. “Leaned In and Out” was very important to a successful interaction with Turntable because it represents that a visitor is fully experimenting with the Turntable by changing positions (and thereby changing speeds) multiple times.

We also analyzed the interview data collected for the Turntable exhibit, as a method of proving the validity of the observation data. Furthermore, we wanted to expand our knowledge of how visitors responded to the video label, so we could draw conclusions on how effective this

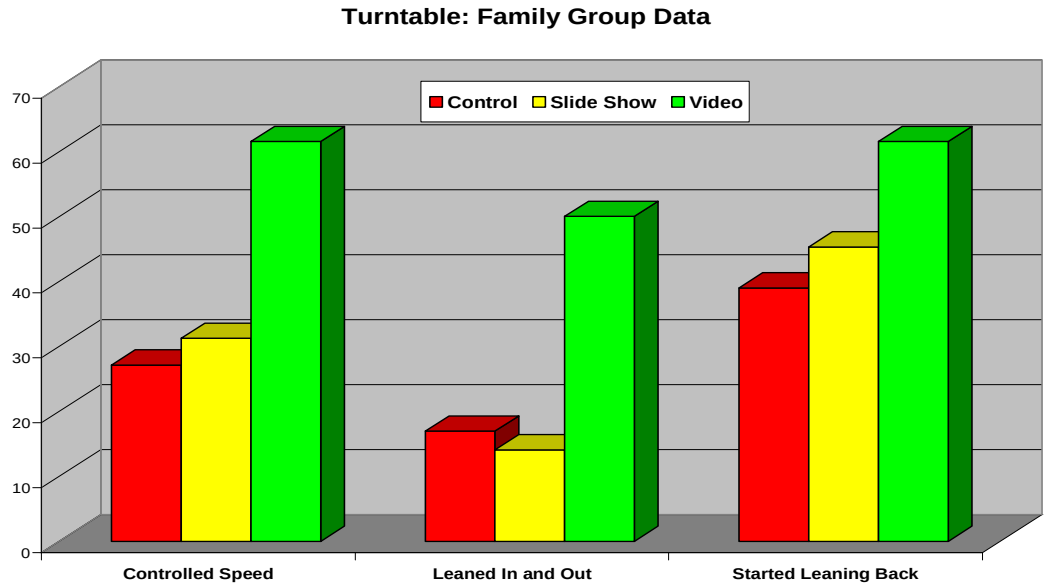

Figure 3: Turntable: Family Group Data

labeling method would be if studied further. Some of the responses we received helped to clarify how well the video and its real life tie were interpreted. For example, one visitor when asked how they knew what to do when they got on the Turntable pointed out the video label, and repeated what was shown perfectly.

"Little computer that tells you what to do, tells you to put your bum in to go fast, bum out to go slower and gives example of ice skater." –Boy, Age 11

This answer also helps to show the success of the real life tie, because not only did the subject mention the exact wording that the video uses to demonstrate speed, but he also related it to the real life tie that the video provides.

For Arch Bridge, a similar method of observation and analysis was used; however no visitor interviews were conducted. Based entirely on our observation data that was collected over a period of a week, the analysis for Arch Bridge helps to reinforce the patterns of success that were demonstrated by the video label on the Turntable. Several important behaviors to a successful interaction with Arch Bridge include a visitor taking apart any previously constructed

bridge, building their own bridge, and then testing the bridge they built by walking across it. Accordingly with the video label in place each one of these key behaviors saw a noticeable increase, especially the percentage of visitors who took apart the bridge that was already present when they arrived at the exhibit. The percentage of visitors who dissembled a previous bridge jumped from 37% in the control group to 52% in the group observed with the video prototype. This is a key behavior to measure when observing for successful interactions with Arch Bridge because if a visitor does not take apart the bridge that is already built when they arrive they will not learn a great deal from any interaction that they have with Arch Bridge. Instead they will simply walk over the bridge that is present and leave, usually not spending more than 10 seconds total at the exhibit.

The base line finding from our research was that adding a visual label to an interactive exhibit fundamentally alters how visitors will use that exhibit, and that the addition of a video label can encourage further experimentation. Furthermore we were able to draw some preliminary conclusions about what visitors will take away from a visual label, and how it will be reflected in their behavior. One of the most predominant examples of behavior being affected by visual labels was the example of children who imitated the cheering and muscle flexing behavior of the explainer from the video, to a degree that suggested they had learned it from the video label.

From our findings from the study of visual labels, we were also able to recommend some possible ideas for future research, to broaden the understanding of how visual labels will affect museum visitors. One suggestion includes studying how a slide show label might work on an exhibit that is not as focused on repeating an exact process as Turntable is. Studying slide show labels on an exhibit such as Arch Bridge might prove to be more worthwhile because it is based on a concrete outcome: a constructed bridge. We also recommend studying how 3D models might improve visitor understanding of an exhibit, because they tend to draw attention and can be tailored specifically to fit the exhibit.

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1.0 INTRODUCTION

In 2006 the United Kingdom is expected to spend £63 billion or the US equivalent of $109 billion on education.[2] This staggering figure demonstrates the importance of education in a fast paced and technologically oriented society like our own. Aside from schools and universities, one large contributor to education in the world today is museums. Museums promote a policy of lifelong learning by imparting knowledge to visitors through exhibits and real life connections. As technology develops and changes, the way that museums convey information must also change.

Figure 4: The London Science Museum

The London Science Museum values and is now trying to integrate technology into each aspect of their exhibits. To guarantee that existing exhibits teach their subject matter in the most effective way possible, the museum needs to analyze how its visitors interact with exhibits. The most basic interaction that takes place between visitors and museum exhibits is reading the instructions. Instructions should demonstrate the best approach to interacting with an exhibit and the way to get the most information out of it. Visitors rarely read long and detailed instructions, however because the average exhibit is expected to receive only about 30 seconds of attention.[3] To the museum, the essential task is to find new ways to give detailed instructions to visitors in the most time efficient manner possible. One possible way to do this is by incorporating new technology where necessary such as instructional videos.

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[2] Her Majesty's Treasury, *Chancellor of the Exchequer's Budget Statement*, http://www.hm-treasury.gov.uk/budget/budget_04/bud_bud04_speech.cfm

[3] Maribeth Back and others, "Designing Innovative Reading Experiences for a Museum Exhibition," *Computer*, January 2001, 80-87

The incorporation of technology into museum exhibits, specifically the concept of using instructional animations rather than written words to convey instructions, is not new.[5] Museums understand and apply the concept that learning visually is easier and more attractive to visitors than learning through reading text.[6] Much of the research available strongly supports this concept.[7] Recent studies have shown that comprehension of mechanical systems specifically is far more dependent on visual representation through a diagram than verbally or through reading text. Essentially this means that a mechanical exhibit can be far more completely explained by a diagram than a text instruction label. Previous WPI projects[8] for the London Science Museum have confirmed this data as well, demonstrating that visitors will pay attention to a visual teaching method far more often, and with more successful results.

Figure 5: Two Visitors Enjoying an Exhibit[4]

The London Science Museum has been making a huge effort (Grant-in-aid by federal funding by Secretary of State in 2001-02: £21 766 000)[9] to improve the quality of its interactive exhibits to effectively educate visitors on the subject matter. It has its own research department devoted to studying how visitors utilize the exhibits, drawing their information from observations and surveying. However the museum staff feels the current methods of instructions such as text labels and still pictures, are not adequately demonstrating to visitors all the features of the exhibit. Specifically, the museum would like to test how effective video instructions could convey information to visitors. With video labels the museum hopes that visitors will both learn how to use the exhibit faster and understand the principles it illustrates more completely.

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[4] Carnegie Science Center, *Zing*, http://www.carnegiesciencecenter.org/default.aspx?pageId=182
[5] Francis Dwyer, *Strategies for improving visual learning: a handbook for the effective selection, design, and use of visualized materials* (State College: Learning Services, 1974)
[6] *Ibid*., 11
[7] The Pennsylvania State University, *How People Learn*, http://tlt.psu.edu/suggestions/research/How_People_Learn.shtml
[8] Exploring Exhibit Extension at the Science Museum, London, UK. WPI Interactive Qualifying Project C Term 2006. http://www.wpi.edu/~lsm
[9] The National Museum of Science & Industry, *Three Year Funding Agreement for the period 1 April 1999 To 31 March 2002*, http://www.nmsi.ac.uk/nmsipages/documents/policy/newfav4.doc

With the incorporation of video labels in its existing exhibits, the London Museum of Science hopes to be able to quickly demonstrate to visitors how to use an exhibit and provide them with specific goals to accomplish, the completion of which will lead to an understanding of the subject matter.

In order to accomplish this we will test the use of video footage on the Turntable and Arch Bridge exhibits in the Launch Pad gallery. This video footage will be a short clip, including footage of explainers demonstrating the exhibit, instructions and real life ties. After this video footage is created, it will be installed next to the exhibit it is explaining. We will also test the effect of a series of static images on the visitors' understanding of the exhibit. To study the effect that visual instructions have on visitor interpretation of the exhibit and its subject matter, surveys will be conducted that are aimed at measuring how much visitors understood of the exhibit and whether or not they read or watched the instructions. The results of this survey will allow us to determine if using video instructions can be connected with increased understanding of exhibit subject matter.

Figure 6: Video used at exhibit[10]

[10] National Electronic & Video Archive of the Crafts, *SOFA Chicago*, http://www.media.uwe.ac.uk/nevac/sofa.htm

2.0 BACKGROUND

When we propose to study how well video instructions will work in a science museum setting, it is important to consider several important topics that are closely tied with science, education, and video learning. To truly understand the scope of this project, education, specifically visual learning, must be considered a primary focus. It is also important to consider how museum exhibits facilitate learning, and the role that text labels play in this learning process. Studying how educational video can affect the learning process is also important, as it allows realistic goals to be set about what our proposed video can achieve. The background section details each of these topics, presenting them in a logical and ordered format.

2.1 Education's Role in Society

The United States Federal Government will spend eighty-eight billion dollars of tax money on education alone this year.[11] This figure, although already staggering, does not take into account money that citizens spend on private college education independent of government funding. For example the cost of the average private college tuition in the United States is now around $21,235[12] per year. This helps to further demonstrate the importance of education in a democratic society. The responsibility of education does not fall completely on the government, however. During the 2004/2005 school year the U.S. Department of Education estimated that 90% of the nationwide $909 billion spent on education was funded through non federal sources.[13] Clearly the importance of education has taken the center stage not just in government but also in society as well.

Education, however, continues to be a difficult topic globally. Recent research shows that approximately 13 percent of the world's 6.4 billion inhabitants can neither read nor write[14]. Even worse is the lack of formal science education received by large parts of the world. As science continues to shape society through technological innovation, it becomes increasingly

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[11] U.S. Department of Education, *Overview - Budget Office - U.S. Department of Education,* http://www.ed.gov/about/overview/budget/index.html?src=gu
[12] CollegeBoard.com, *2005-06 College Costs,* http://www.collegeboard.com/student/pay/add-it-up/4494.html
[13] U.S. Department of Education, *Overview – The Federal Role in Education,* http://www.ed.gov/about/overview/fed/role.html?src=ln
[14] Central Intelligence Agency, *CIA – The World Factbook,* http://www.cia.gov/cia/publications/factbook/geos/xx.html

more important that every person understands at least some basic scientific principles. People tend to ignore or even fear change that they cannot control or understand. This makes it essential for society to understand scientific innovations rather than reject them. As new research emerges, it must first be comprehended by society before it can be implemented to create a change.

2.2 The Role of Museums in Education

With such a modern focus on teaching science, governments attempt to educate through a variety of systems. In many nations science museums are an important contributor, which help by illustrating scientific principles to the general population using interesting and effective methods. In the United States alone there are approximately 17,500[15] museums, while the United Kingdom is host to over 2000[16] museums. These museums create and foster an environment in which a variety of people are reached and educational goals conveyed.

Each museum shares the same basic goal of educating its visitors in topics that are the very basis of our culture and society. Because museums set a goal of educating visitors in important topics, this also tends to be how they measure and recognize their success. Therefore, it is a central goal of any museum to find the best way to make visitors learn. Research has proven that one of the most effective ways to do this is through the use of educational material that is connected to real life[17] which the regular visitor of a museum can easily relate to his own experience. Because science is traditionally taught by simply stating a series of facts or laws, many everyday people are turned off to learning it. However many experts, such as John Dewey, believe that science should be taught simply, as one experience that can be built upon and interpreted easily during the learning process. Dewey believes that science should be presented as a series of tools and concepts that make each previous experience easier and more accessible. Essentially education should be a continuing process or reconstruction of previous experiences.[18] Museums use this as a cornerstone to build a method of educating visitors through interactive exhibits.

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[15] American Association of Museums, *ABCs of Museums*, http://www.aam-us.org/aboutmuseums/abc.cfm#how_many

[16] Museum Association, *Frequently Asked Questions*, http://www.museumsassociation.org/faq&_IXPOS_=mahead6

[17] Stevens, R. and Hall, R., "Seeing Tornado: How Video Traces mediate visitor understandings of (natural?) spectacles in a science museum", *Science Education*, 18(6) (1997): 735-748.

[18] Ansbacher, Ted, *Interview with John Dewey on Science Education*, http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/deweyonscied.pdf

2.3 Importance of Museums

The different approaches to learning utilized by museums make them an essential part of society. Museums give children a chance to learn outside the classroom. Ted Ansbacher believes that genuine learning is a continuous process in which we have experiences with the world around us, find commonalities and then compare them to our experiences. This is how children learn, by exploring their world. This is also the same process scientists use when trying to understand the world. Experience is central in both cases. Interactive exhibits provide the perfect opportunity for this type of learning to take place.[20] One of the major goals of an interactive exhibit is to connect the concept the visitor sees in the museum to something closer to them that they can experience in their everyday lives. Museums want visitors to take the concept they learn and be able to explore it further in their normal exploration of the world. Museums would like to get the point across to their visitors that everything they see and experience in the museum can be seen and experienced in their everyday lives. This allows visitors to understand and remember exhibits better.[21] The visitors' process is the most important part of an interactive exhibit. Through the process of interacting with the exhibit, the visitors are gaining skills and knowledge that are not easy to communicate otherwise. These skills help the visitors continue

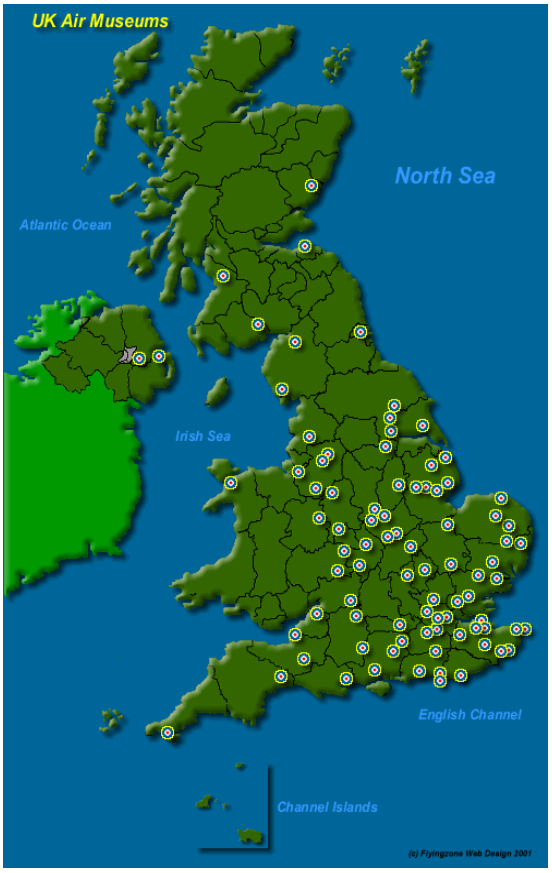

Figure 7: Locations of Air Museums in UK[19]

[19] Flyingzonedirect, *Flyingzonedirect's UK Air Museum Locator Map*, http://www.flyingzonedirect.com/airmuseums/museummap/museummap.htm
[20] Ansbacher, Ted, *"Real" Reality: The Future for Exhibits*, http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/realreality.pdf.
[21] Ansbacher, Ted, *Misunderstandings of Meaning Making*, http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/mythsofmm.pdf

their process in their everyday lives. More importantly, it is only through this interactive process that visitors are able to obtain a deeper level of understanding in the short time they are interacting with the exhibit.[22]

The natural process of learning that can be seen in young children involves exploration and experimentation with the world around them. Scientists use a similar approach when attempting to understand a phenomenon. Traditional forms of education have taken a different approach which is based on a teacher lecturing students and giving them a set of facts and laws. This style does not allow the student to connect with the material in a way that enables them to discover and test it themselves.[23] For example, children are given a set of rules to follow by the adults taking care of them. This is similar to the set of rules or laws that a teacher would pass on to his or her students. A child may be told not to touch the stove because it is hot. Some children may listen and believe the adult but never deeply understand the meaning of that rule. This is similar to a teacher telling a student that gravity affects everything and that everything you throw up in the air will come back down. Trusting students might believe the teacher but may never completely understand what he or she meant. Now if that child were to touch a hot stove and get burnt or that student were to throw a ball in the air and get hit on the head, they might understand what their parent or teacher was trying to teach them. This same concept can be applied in museums through interactive exhibits that illustrate a concept rather then just state the fact that it is true.

2.4 Interactive Exhibits

An interactive, or experience based exhibit, is an exhibit that teaches a concept to a museum visitor through interaction and experience. This is in contrast to a non interactive, or information based exhibit, that states facts for visitors to learn. For example, a classic interactive exhibit would be a series of marble tracks lined up together, each with different slopes but the same overall length (See Figure 8). The visitor interacts with the exhibit by racing the marbles down the slopes, to see which one is faster. The opposite would be a non interactive exhibit, which involves no input from the visitor aside from perhaps a small amount of attention. An

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[22] Ansbacher, Ted, *Rethinking our Goals: Putting Process First*, http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/rethinkinggoals.pdf

[23] Ansbacher, Ted, *"Real" Reality: The Future for Exhibits*, http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/realreality.pdf.

example of a non interactive exhibit would be a series of labels explaining a roped off F1 racecar. The racecar is there to see and read about only, not to touch or interact with.

The clearest difference between these types of exhibits lies in their use of labels. Labels for information based exhibits are central to the exhibit as they tell what the exhibit is about and contain all the information about that exhibit. Labels for experience-based exhibits play a more supportive role to the exhibit, teaching visitors how to use the exhibit and encouraging further inquiry (See Figure 9).[24] The goal of an interactive exhibit is to let visitors learn through their natural process of experience. This allows visitors to learn while developing skills and hopefully gaining a sense of inquiry into the subject explored by the exhibit.[25]

Museums traditionally measure the success of their exhibits based on the amount of information passed on to their visitors. However, the success of interactive exhibits should be measured based on the information transmitted as well as the visitors' understanding of the concepts and inquiry into the subject.[26] Labels used in information based, or non-interactive exhibits are meant to strengthen the message that the exhibit is conveying. In most cases these labels are the only way the message can be conveyed and become the focus of the exhibit.[27] Labels used in interactive exhibit are

Figure 8: The "Racing Slides" Exhibit at the Boston Science Museum

[24] Ansbacher, Ted, *What did you see and do?: A Brief Introduction to Experience-based Exhibits,* http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/briefintro.pdf
[25] Ansbacher, Ted, *Rethinking our Goals: Putting Process First,* http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/rethinkinggoals.pdf
[26] *Idem.*
[27] Ansbacher, Ted, *Experience, Inquiry, and Making Meaning,* http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/expinquirymm.pdf

meant to facilitate the use of the exhibit. They should play a supportive role to the exhibit, helping visitors understand the exhibit and encouraging further inquiry into the subject explored by the exhibit. Labels for interactive exhibits should also connect the visitor's experience with their everyday lives.[28]

2.5 Limits of Labels

Labeling is useful in a museum setting as a method of passing on instructions; however it has its limitations. Simply put; "People only usually spend a few seconds reading a label."[29] That is often not a problem of the label itself, but rather of its placement: "An interpretive label that blends into the background may be ignored because it lacks attention-getting power."[30] Other problems with attention-getting power include poor line-of-sight placement, or that the label is not easily spotted by visitors. The label should never be placed more than 6 feet off the floor because visitors tend to never look up. Also, lighting should be spot-lit, and create a contrast between the label and its surroundings.[31] Often times even properly placed labels are ignored. This is primarily because each visitor usually devotes only about 30 seconds to the average exhibit. [32]

Figure 9: Text Label at the Boston Science Museum

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[28] *Idem.*
[29] Kelly, Lynda, *Writing text and labels: a review of the literature*, http://www.amonline.net.au/amarc/pdf/research/text.pdf
[30] Stephen Bitgood, "The Role of Attention in Designing Effective Interpretive labels," *Journal of Interpretation Research* 5, no. 2: 31-45
[31] *Idem.*
[32] Maribeth Back and others, "Designing Innovative Reading Experiences for a Museum Exhibition," *Computer*, January 2001, 80-87.

2.6 Mechanical Reasoning

Clearly text labels are not the ideal solution for communicating instructions to visitors. For mechanical interactive exhibits, however, the problem is compounded further. Museum exhibits are designed with the intention of teaching scientific principles to visitors. However learning about mechanical systems takes place differently than other scientific principles. A mechanical exhibit, by definition, is a mechanical system. Humans understand mechanical systems by making *mechanical inferences* about how the system works. Any mental process that allows us to derive information about how things move is described as a mechanical inference. This is closely associated with mental or spatial representation of the mechanical system. Mental representation, the process described above, is an example of what is called *mechanical reasoning*, which is the cognitive process used by the individual when trying to understand the mechanical system demonstrated, or in other words the process of making *mechanical inferences*. It can either rely on explicit knowledge; that is, the knowledge of basic physics, or on mental simulation. It is important to realize that mental simulation bypasses the verbal formulation of the physical law or situation involved, instead relying on "internal spatial representation of mechanical systems… and can be dissociated from reasoning based on descriptive representations or explicit knowledge."[33] Thus, if a visual conveys information about the functionality of a mechanical exhibit directly to the spatio-visual component of the visitor's mind, it will provide a better understanding of the exhibit to the visitor, because it will be easier for spatial representation to occur. Simply put; when describing a mechanical exhibit, visual imagery, such as a video or picture, is much more effective at conveying information about how a mechanical system works than is text.

[33] Mary Hegarty, "Mechanical reasoning by mental simulation," *Trends in Cognitive Sciences* 8, no. 6, (2004): 280-285.

2.7 Visual and Interactive Learning

Visual learning is learning from visual instructions. That includes using any kind of material that is related to the sense of sight, with the exception of written text, which relies on the verbal ability and is closer to lecturing than visual instruction.[35] Visual and interactive learning are important because people learn more from visuals than they do from simply reading or being lectured. Figure 10 shows how humans use their senses to receive information (See Figure 10).

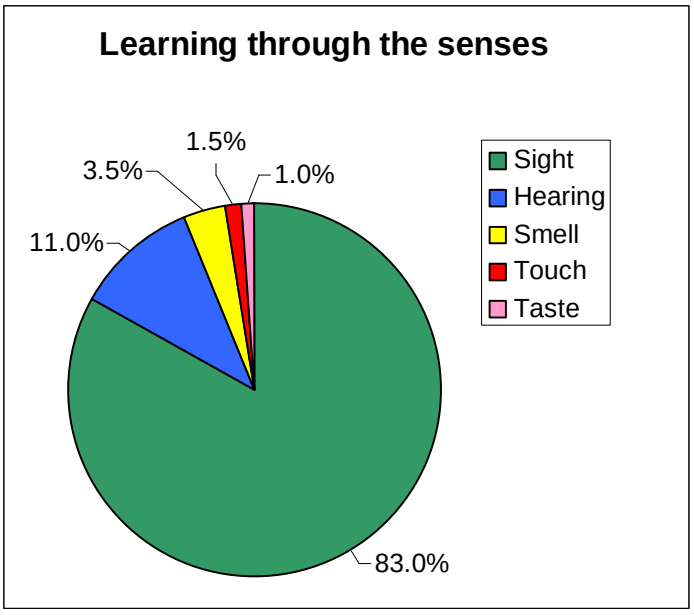

Figure 10: Learning through the senses[34]

Figure 11 shows graphically how presentation of information affects memory performance (See Figure 11). Most notably, Figure 8 demonstrates that 90% of information obtained by active participation and conversation simultaneously is recalled. The effect of watching information presented without any interaction, like a video, has a 30% chance of being successfully recalled, as opposed to a 10% chance if information is simply read. This shows that a proper visual instruction is much more likely to be perceived and remembered than speech or text on the same subject. This is assuming, however, that the visual instruction is in fact used for an appropriate subject matter, which can not always be the case: "there are situations where clear language is as effective as graphics."[36] For a more thorough comparison refer to APPENDIX A.

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[34] Francis Dwyer, *Strategies for improving visual learning: a handbook for the effective selection, design, and use of visualized materials* (State College: Learning Services, 1974)
[35] Francis Dwyer, *Strategies for improving visual learning: a handbook for the effective selection, design, and use of visualized materials* (State College: Learning Services, 1974)
[36] Tversky, B., Morrison, J. B., and Bétrancourt M., "Animation: Can it facilitate?" *International Journal of Human-Computer Studies* 57, (2002): 247-262.

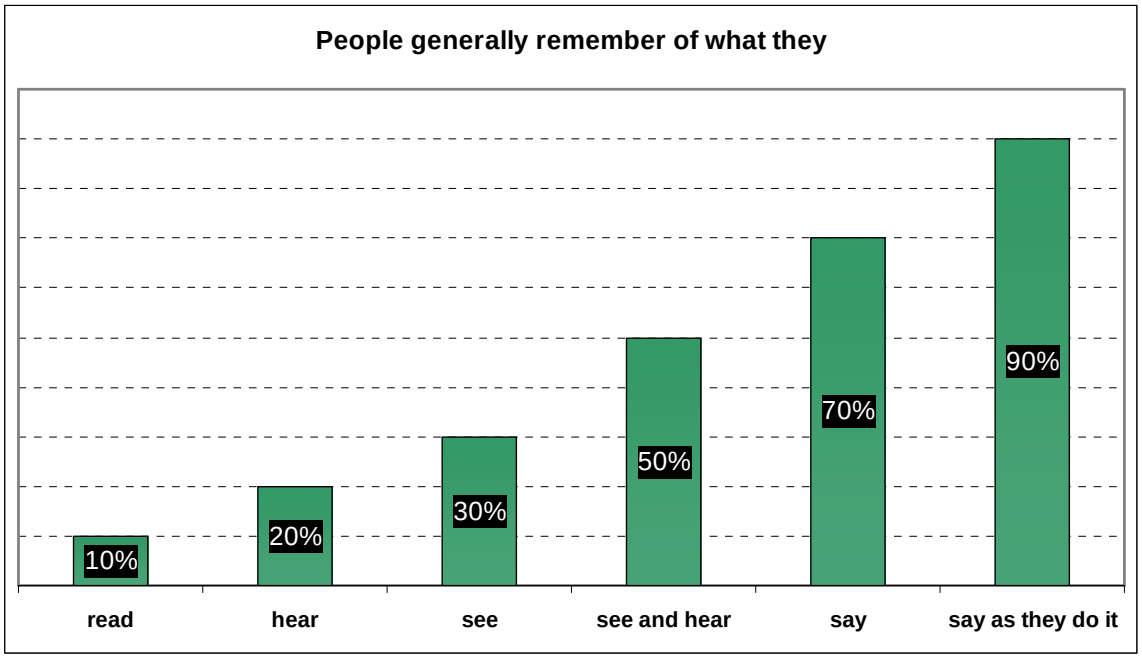

Figure 11: How presentation affects memory

2.8 Effective Visual Learning

For an instructional video to be successful several important aspects must be taken into consideration. First any instructional video must be attention grabbing. This means that it is vital that the video be isolated so that no other visuals distract the viewer from it. Furthermore it must be displayed large enough so it can be seen from a distance. Even more importantly is that the video must follow the same line of sight rules for placement of text labels, including the right distance from the floor. Also it is good to consider the background so that the video has the right amount of contrast with it.[37]

The content of the video must also be carefully considered when designing an instructional animation. First, all the video must correctly and accurately depict the exhibit it is displaying, without getting lost in the details. This means attention must be paid to exactly what is expected to be taken away from the video. Research has proven that simple, less detailed

[37] Stephen Bitgood, "The Role of Attention in Designing Effective Interpretive labels," *Journal of Interpretation Research* 5, no. 2: 31-45

visuals are often more effective than realistic ones, provided that they contain the information that is expected to be conveyed.[38]

Often times instructional videos can fail because they are unsuccessful in meeting the above criteria. A common problem is that the videos are misplaced, so that visitors end up never seeing them in the first place. Also the content of the video can be too vague or abstract for the visitor to be able to relate it to the exhibit. Another frequent difficulty occurs when the video is too low quality for visitors to justify spending the time to watch it.[39]

2.9 Launch Pad, Turntable, and Arch Bridge

The most important aspect is how the background information will be applied to Launch Pad, and the Turntable exhibit in particular. Launch Pad is an interactive gallery made for children ranging from ages 8-14. It is comprised of over 25 hands-on exhibits. It is an area frequented by school and family groups both inside and outside the intended age range. The gallery tends to attract younger children because of its design and the overall feeling you get stepping into it. The museum plans on moving this gallery to a different area of the museum and hopes to remedy the age range problem by changing the design and adding, updating, or removing some exhibits.

One of the exhibits that either needs to be changed or removed is the Turntable. The Turntable exhibit in Launch Pad is designed to demonstrate the principals of angular momentum. The exhibit is simply a free spinning platform with footprints with a padded pole coming out of it with two rope handles surrounded by a circular padded barrier. The object is to stand on the platform with your feet on the footprints, hold the handles and lean back while keeping your legs straight. Then you start spinning slowly by either pushing off with your foot or having someone push you.

Figure 12: Turntable Exhibit in Launch Pad Gallery

[38] Tversky, B., Morrison, J. B., and Bétrancourt M., "Animation: Can it facilitate?" *International Journal of Human-Computer Studies* 57, (2002): 247-262.
[39] *Idem*.

Once you are spinning you are supposed to stand up straight and through conservation of angular momentum you will start to spin much faster then you had been without a push. You are also supposed to lean out again to slow down. The proper usage of this exhibit is not intuitive and requires direction either from the label or from an explainer. Part of this is due to the fact that the exhibit looks like a common piece of playground equipment. The common usage observed is children just spinning as fast as they can, controlling their speed with their feet or with help from another person. This exhibit has been a problem for the museum since its installation. It is usually not used correctly and when it is used correctly, the user usually does not understand the concept being demonstrated. The exhibit is misused more often than not and the museum does not plan to move it into the new Launch Pad. We are hoping that we will be able to remedy the misusage problem using visual rather then text labels.

Arch Bridge is another exhibit in the Launch Pad gallery. It is designed to demonstrate the principle of how arches distribute forces. In this exhibit visitors can build their own bridge and then walk across it to test its strength. It is a large exhibit that consists of five red blocks that form the span of the bridge and go between two abutments with a large backboard. The exhibit also has two supports which are meant to help the visitors build the bridge by holding the blocks up while they are making the bridge. However, we chose to test the use of the exhibit without these supports for a variety of reasons. From the museum's past experiences the use of the supports leads to a poor bridge being constructed. Also the museum would like to encourage families or group of children and adults working together to build the bridge, while the supports encourage children to build the bridge on their own. We chose to work with this exhibit because there were some common misuses that could hopefully be remedied easily. Some of these misuses include walking over a bridge made by a previous group, or not placing the blocks correctly. This exhibit illustrates a simple concept

Figure 13: Arch Bridge Exhibit in Launch Pad Gallery

that is easily connected to real life examples that visitors have experienced. A video label may help increase correct usage of the exhibit and therefore increase understanding of the concept.

3.0 METHODOLOGY

Our project is aimed at helping the London Science Museum promote lifelong learning and increase visitor satisfaction by designing, implementing, and testing visual instructions on popular mechanical exhibits specifically intended for children ages 8 – 14 years old. Our project is centered on researching and testing how visitors of the museum respond to visual learning, and to propose a strategy where the museum can use visual learning to improve the visitor experience. To accomplish our goal, we have outlined several objectives that will need to be completed.

1. Test the effectiveness of current exhibit instructions
2. Design and implement visual instructions
3. Test the effect of our visual instructions

Steps two and three of our objectives were repeated several times throughout the course of the project. Each time we changed the visual instructions, we had to survey the result, to determine which type of visual label proved more successful in teaching the concept of the exhibit, as well as how to properly use the exhibit.

3.1 Evaluating Current Exhibit Instructions

The first step was to choose a Launch Pad exhibit to test visual instructions on, based on how visitors interact with the exhibit before any instructional change was made. Next we gathered survey data about the exhibit we chose, through observation and interviews with museum visitors, as well as the explainer staff at the museum. We used this data as a baseline to determine the effects of adding visual instructions to a particular exhibit.

3.1.1 Choosing an Exhibit

The first exhibit that we worked on was chosen for us by the visitor research department and the head of the Launch Pad team. The decision to work on one particular exhibit, the Turntable, was made at a Launch Pad Planning meeting. During this meeting several other exhibits were also selected as candidates for video instructions. We began by focusing only on the Turntable, which was chosen as a candidate for video instructions because visitors were not interacting with it successfully. The idea behind the Turntable is to teach the basic concept of

conservation of angular momentum to children by demonstrating that standing straight up on the Turntable will make the subject rotate faster than when leaning back. The exhibit works by providing a circular plate for visitors to stand on, with a pole attached to hold on to. (See Figure 12) The visitor is supposed to push off the floor with their feet and spin around. As they spin, the visitor is directed to lean back, and notice how they spin slower than before. By noticing this difference in rotation speed, they are beginning to grasp the basics of angular momentum. However in practice this rarely happened. Typically a visitor would simply spin on the Turntable for a brief period of time, and then step off and walk away. Sometimes children who approached the exhibit would even take their shoes off and use the Turntable, despite the fact that this had absolutely nothing to do with the experiment or the exhibit. The museum's staff has no idea as to why this happens, but it is one of the problems that we hoped to fix by adding video instructions.

We chose the second exhibit to add visual instructions to by asking for recommendations from the team that is designing the new Launch Pad, as well as staff from the visitor research department and the explainers. Getting input from several different departments within the museum helped us to get a good idea of which exhibits were in need of instructional revisions. Also by talking to the Launch Pad team we were able to know which of the exhibits we were deciding between are going to be moved to the new Launch Pad in 2007. If an exhibit was not going to be included in the new Launch Pad we did not consider that exhibit because we decided we wanted to work with an exhibit that the museum has an interest in keeping and improving upon.

After taking the opinions of the departments in the museum that are involved in the Launch Pad, we decided to work with Arch Bridge as a second exhibit. Arch Bridge was chosen for several reasons, the most important being that it is an exhibit that is designed to produce an actual concrete physical product after the interaction, rather than being based on a process. In other words the final product of Arch Bridge is, in an ideal situation, a five block bridge that children and adults can walk across safely. Turntable however is a process focused exhibit; there is no concrete outcome, and instead the visitor is supposed to go through the process of using Turntable correctly rather than create something. Arch Bridge was targeted because it is an outcome based exhibit, which makes gathering data on it more straightforward than Turntable. The differences in data collection methods are explained in further detail in sections 3.1.3 and

3.1.4, however the basic overview is Arch Bridge only required the collection of observation data, as opposed to Turntable which required observation data coupled with visitor interviews.

The Arch Bridge exhibit is designed to teach children about arches, including how and why they are used in man made structures. Also the exhibit demonstrates the concepts of forces, keystones, bridges, and structures. The visitor is supposed to make an arch shaped bridge over a small gap using 5 identical wooden blocks (stones) that fit together perfectly. Then the visitor is instructed to test their creation by walking over it and seeing how easily it can support their weight. The problem with Arch Bridge is that visitors do not invest enough time into making their own bridge and testing it. In fact many of the visitor interactions that occur with Arch Bridge are less than 15 seconds in length. In other words this means that visitors are simply walking over an already built bridge, and then leaving to use another exhibit. A longer average interaction time would be one indicator of success for Arch Bridge, which would show that visitors are investing the time to disassemble the existing bridge and create their own.

3.1.2 Surveying Museum Explainers

After we decided which exhibits we were going to be working with, the next step was to evaluate the instructions of the target exhibits. Evaluating how successful an exhibit's instructions were required using a balance of visitor data results as well as survey data collected from the explainers in the Launch Pad. To collect this data, we used the Explainer Survey Forms which were designed to receive explainer input on how successful an exhibit's instructions were at conveying correct use and scientific concepts. To evaluate these criteria, we asked the explainer's to give a rating from 1 to 5 of a series of questions about the exhibit. The questions asked the explainers to rate both how clear the exhibit's instructions are, and how often people use the exhibit correctly. The survey also asked the explainers how often people read the instructions. Finally, the survey asked what the explainers themselves would do to the instructions to make them clearer to visitors if given the opportunity.

To distribute the explainer survey, we attended one of the explainer meetings. This allowed us to distribute the surveys easily, and get responses within minutes. This saved us time because we did not have to approach them individually. We also asked the explainers to provide their names on the survey form, just for the purposes of being able to tell who had taken the survey, and who had not. This way we would have been able to provide the explainer team

leaders with a list of everyone who had taken the survey, so that if responses were low, the team leaders would have been able to help encourage the rest of the explainers to participate.

We did not survey the explainers on how they felt the visual instructions helped the target exhibit, because logistically it was too difficult to make sure they got to spend enough time with the new instruction prototypes to evaluate how well they worked. This was because there are about 50 explainers working for the museum, each with a different work schedule. However, each prototype was only installed while we were actively testing it, which was not a sufficient length of time for the majority of the explainers to work in the Launch Pad with it. That meant that we would not be using the explainer survey data to make a direct before and after comparison, but instead we chose to use it to support our before visual instruction data obtained from visitors. We also used the answers to the open ended questions we asked to help make the exhibit's instructions demonstrate proper use more completely. The open ended questions asked what changes the explainers would make to the text instruction set to make them easier for visitors to learn how to use the exhibit. Answers to these questions were taken into consideration when the visual instructions were designed.

The exact survey form used to survey the explainers about Turntable was the Turntable Exhibit Survey (See APPENDIX B). The exact survey form used to survey the explainers about Arch Bridge was the Arch Bridge Exhibit Survey. (See APPENDIX C). The only item that was added to the Arch Bridge Survey was a question asking if the explainers believed the supports for Arch Bridge help visitors construct a better bridge. This information was collected so we could make a recommendation to the museum about whether the supports should or should not be included in any future versions of instructional videos. We decided to not include the supports when we did our observations for Arch Bridge, because the benefits and drawbacks of the supports is a heavily debated topic in the museum, and because they present a lot more variables to measure.

3.1.3 Observing Museum Visitors

The next step was to gather observation and interview data from visitors simultaneously, before any change was made to the instructions. Observation data, along with data collected from visitor interviews, was used in combination to determine how effective an exhibit's instructions are at promoting proper use, teaching basic scientific principles, and tying the

science behind the exhibit to real life. Visitor observation data was gathered at the same time interviews were conducted, so that for each visitor interviewed, we also gathered a set of observed behaviors that we could relate to the interview. This was helpful in connecting what a visitor did when using Turntable, to what they were attempting to do, where they learned how to use the Turntable, and who helped them along in the process. For example we observed a visitor using the Turntable perfectly without being helped by an explainer. Using the interview data we were able to determine that the visitor watched the instructional section of the video, and then studied the visitors using the Turntable while he waited in line. If such a pattern presents itself in several different interviews then we could make a note of it, and draw conclusions from it, as well as suggest further hypotheses to study.

To collect visitor observation data for Turntable, we used the pre-coded observation sheets (See APPENDIX D) which were tailored for Turntable specifically. The observation forms were pre-coded for several reasons. First, using a pre-coded sheet made writing down observations easier. Normally when the museum does observations they note down visitor behaviors on a sheet of paper and then have to review it and code it afterwards. This means that each behavior has to be written down in abbreviations, along with interaction time, age, gender, and any other comments. The problem with doing this with Turntable was the typical interaction was around 24 seconds[40] and getting all that data down in such a short period of time was very difficult. Using the pre-coded sheet two people working together were able to get all the variables we were observing written down without any confusion. The second reason we used the pre-coded observation sheet was that it made analyzing the data quicker, because we did not have to go through notes and decide what was categorized as a certain behavior.

To ensure that all of the typical behaviors that occur at an exhibit were included on the observation sheet, we pre-tested each form before we gathered any real usable data (See APPENDIX E). Pre-testing involved using the most recent version of the form to observe 10 or 15 visitors, and note down any problems that occurred because the sheet was not set up correctly. Then the changes were made and the new observation sheet was pre-tested again. This was repeated until no major problems were discovered. If a problem occurred while we were

[40] Taken from the average of the time of interaction in our observation data before any instructional change.

collecting the real data, such as a behavior was observed that was not on the sheet, then that behavior was written down under comments so it could be analyzed as well.

When we observed Arch Bridge, we used the same method of pre-testing to create a pre-coded observation sheet. (See APPENDIX F). The observation sheet for Arch Bridge focus on what visitors do with the time that they spend at Arch Bridge by providing a system to evaluate how they built the bridge, how many people were involved, the quality of the bridge that was constructed, and if the visitor walked on the bridge that they built. The sheet also asks what role the adults who were present during the interaction had with the construction of the bridge. This was an important variable to test because the museum staff feels that the most successful interactions with Arch Bridge usually occur when an adult helps the child by either giving verbal instructions or physically helping to construct the bridge. We measured how often adults helped build Arch Bridge before any instructional change was made, and correlated it with the quality of the bridge built. This provided us with a way to measure if the visual instructions for Arch Bridge would encourage children to get an adult to help with the construction of the bridge, and if a better quality bridge resulted. To evaluate the quality of a bridge, we used a scale of one to five, with five being a perfectly constructed bridge with evenly lined up blocks, and a one representing a bridge that was too unstable to walk over without collapsing. (See APPENDIX G)

3.1.4 Interviewing Museum Visitors

Our next task was to gather interview data for the Turntable exhibit. To collect information about how visitors interact with exhibits, we designed questionnaires that were focused on evaluating how well exhibits convey their instructions to visitors. Interviews proved to be an ideal method to collect data on how visitors interact with exhibits because they allowed us to get a fairly accurate estimation of how much a visitor learned from an exhibit, by asking the visitors what they thought the exhibit was teaching. Also through the use of interviews we were able to get visitor opinions on how effective the current instructions were, and information on what they liked or disliked about the exhibit instructions. One more benefit of using interviews was that interviews typically receive a much better response from visitors as opposed to a phone survey or e-mail questionnaire.[41]

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[41] Ben Gammon, *Effective questionnaires for all, A step by step recipe for successful questionnaire* (2001)

We conducted the interviews immediately after the visitors used the exhibit, so that we could make sure the information was still fresh in their minds. Because the Launch Pad exhibits are targeted at children ages 8 – 14, we directed our surveying towards children that fall in or around that age group, and did not survey anyone outside of that age group. Deciding which visitors were interviewed was done systematically to obtain a random sample. We interviewed every third observed visitor to the Turntable, provided they are the correct age. If a visitor chose to not take the interview, or did not have parents or teachers present to provide consent, then we attempted to interview the next visitor of the correct age, and so on until we got a participant. Because we did not choose the interviewee by anything else other than the order that they used the exhibit, it was a valid random sample. Also it was independent from the slide show and video samples because the order was not influenced by our judgment. This allowed us to analyze the sample as an independent random sample and use common statistical methods.

To gather interview data, we used the Exhibit Evaluation Form (See APPENDIX H), and we conducted interviews with visitors for several days. We surveyed both family groups and school groups, by conducting interviews during weekdays, weekends, and half-term, which is school vacation in the UK. Surveying both school groups and family groups was important, because the two groups behave very differently in the Launch Pad. In a family group more adults are present typically, children are more supervised, and therefore tend to interact with exhibits more successfully. In school groups there are usually fewer adults (the museum requires only 1 adult for every 8 children in a class) so the children are not as well supervised and do not receive the same guidance with using exhibits than they would if a parent or family member was present.

We broke up the surveys by conducting 15 on weekdays and 15 on weekend or school vacation days, for each change made to the exhibit. This divided our data gathering into 6 different categories; control, slide show, and video, and each has a weekday and a weekend data set. We decided on conducting 15 surveys for each data set because it was a realistically obtainable amount that would not take more time to collect than we had available to us. We also wanted to ensure that we could analyze the data and still have enough time to collect more data if necessary.

We conducted the surveys in an interview format, with one group member asking questions and another taking the notes. Survey questions were aimed at qualitatively evaluating how much a visitor learned from an exhibit, how enjoyable it was, and if using the exhibit was

straightforward or not. Surveys were employed for several reasons, the most important of which was that surveys were able to provide us with nearly instantaneous feedback on a specific exhibit, or even part of an exhibit, before visitors left the museum and forgot crucial details. Also surveys can be designed so that data is accurate, provided that necessary steps are taken when designing the survey.

Such steps included making sure the phrasing of a question did not give away to a visitor how it is supposed to be answered. Also when designing our survey we made sure that the questions we really needed answers to, like did you read the instructions, were asked more than once in slightly different ways. This reduces the chance that visitors will be able to lie without an answer conflicting with one given before. The benefit in using this method was that conflicting answers that threatened the validity of our data could be eliminated during the analysis of the data.

Designing questionnaires to measure how well instructions convey a concept to an adolescent visitor proved to be a complicated task, because questionnaires have to be carefully set up to record accurate data. When designing surveys we referred to the list of survey problems and tips (See APPENDIX I), as well as the Questionnaire Recipe Book[42] designed by the museum staff. These resources pointed out some of the common problems that occur when interviewing in a museum setting, and provided helpful insight into avoiding or correcting them. Typical problems include situations where the survey subject will try to second guess the researcher, and tell them what he or she wants to hear. Also problems can arise when the researcher does not communicate effectively with the subject, and therefore the subject is forced to answer a question that they may not understand. Problems like this can skew survey data, and make it difficult to get a reliable analysis.

With each survey we conducted, we were wary of visitors that could complicate data. When interviewing children, a very common problem that can arise is a child's parent helping the child answer interview questions or restating the question to them. This is a big problem because it is important that the child answers the questions in the way that we wrote them on the survey. To deal with this problem, we informed the parents that they cannot assist their child on the survey because it will skew the results. If a parent continued to help the child through the interview, we simply ended the interview, thanked them for their time, and left.

[42] Ben Gammon, *Effective questionnaires for all, A step by step recipe for successful questionnaire* (2001)

For our surveying done in the museum we were aiming to set up the surveys in a way that allowed us to answer the critical questions we have, but not make the survey too long so that visitors got bored. The questions we asked about the Turntable exhibit were designed to evaluate how well the visitor used the exhibit, and how effectively the science behind Turntable was conveyed to the visitor. Because we interviewed children, it was important to consider how we would attract them to take the survey in the first place. However, for the most part visitors were willing to be interviewed, mostly because they wanted to help us make the museum a better place. However if a visitor did not want to take the survey, we simply thanked them for their time and left. Typically when the museum staff conducts interviews with children, they reward them with a sticker after the interview is completed. We chose to also give out stickers to children who completed our survey, to thank them for their help. This was more of a reward than an incentive, because the children were not told about it until the survey was complete.

For a quick summary please refer to APPENDIX J.

3.2 Designing Visual Instructions

Our next step was the designing, filming, and editing the visual instructions for the exhibits we worked with. Careful planning had to go into the content of the visual instructions, as well as the decisions like length and placement of the video on the exhibit (See APPENDIX K). In order to achieve the best result the video had to include several key elements. The first and most important element in each set of visual instructions was the section detailing how to interact with the exhibit properly. This instructional "How To" section was included in each set of visual instructions we produced, no matter if it was a slide show or a video.

Following the instructional section was a brief section that related the science that the exhibit is built on to real life. This section was called the "Real Life Connection" segment of the instructions, and it was only included in the Turntable instructional video.

In order to ensure that the visual instructions are as complete and comprehensive as possible, we used the suggestions given to us by the explainer staff through the Explainer Survey, which contained several open ended questions asking for suggestions on how to change the target exhibit's instructions to make them more clear to visitors. These suggestions were taken into consideration as we planned the content and layout of the new instructions.

3.2.1 Designing the Slide Show Label

The first visual instruction set we tested was a series of still images that displayed proper use of the target exhibit. This series of images, or slide show, was directed only at conveying how to use the exhibit correctly, and did not present any real life connections. The real life connections were omitted in the slide show because of the length of time it would take to make a complete cycle through all of the slides if more images were added. Each slide in the slide show must be displayed for at least 5 seconds on the screen, as a factory preset. Because we could not expect a visitor to spend more than 30 seconds looking at instructions, we did not make a set of instructions that took longer than 30 seconds to make a complete loop. It was also important to realize that the longer the slide show was, the smaller the chance that a visitor would see the beginning of the show where important information about how to start interacting with the exhibit was given. Using 30 seconds as a maximum length of time for the instructions, we were limited to 6 slides at most. Explaining the proper use of the exhibit was possible in fewer than six slides, but realistically it was not possible to completely add a tie to real life as well.

To design the slides, we first began by finding out what, precisely, a perfect interaction was on the exhibit we were working on. For this we talked to the explainers who spend everyday instructing visitors in the proper use of the Launch Pad exhibits. They are experts at conveying the use and scientific concepts of each exhibit to children, so their help was valuable when deciding what to include in the slide show. After talking to the explainers, we were able to identify the key steps that the slide show should include to promote the best interactions with the exhibit we worked with. Knowing which steps are important to the interaction is essential when creating a slide show because processes and motions that are intended to be duplicated in real life are very difficult to illustrate as still images. Identifying the most significant stages of the interaction process enabled us to schematically illustrate the correct use of the exhibit with a slide show.

3.2.1.1 Designing the Slide Show Label: Turntable Specifics

When designing the slide show label for the Turntable exhibit, we first identified three key stages that the explainers agreed were necessary in order to instruct visitors how to correctly use the exhibit. This we obtained through informal interviews and instructional demonstrations with the explainers that were very familiar with Turntable. We learned that the visitors should

first start spinning slowly while leaning back, then gain speed as they lean in and bring their mass closer to the axis of rotation. Finally the visitors are supposed to slow down again by leaning back out. To illustrate these three steps, we created one slide for each action. (See APPENDIX L) The first slide required more written instructions than the others because it is difficult to visually explain that starting slowly is recommended. We therefore displayed this first slide twice as long as the other slides, to ensure that children were given adequate time to read and understand the instructions.

To make sure the slides were easily understandable and clear to children of our target audience, we used a simple stick figure to illustrate the correct use of the Turntable. This also permitted us to address a wider audience than the targeted 8-14 year old children with our slide show, because a stick figure is neutral and is not necessarily associated with an adult or a child. Using black stick figures on a white background also helped us to maintain a readable contrast throughout the slideshow.

We also added a simple gauge that indicates the speed with which the visitor is turning on the Turntable to make the slide show more comprehensible for children without using many words. A basic speedometer can illustrate the change in speed to children that cannot read or visitors that do not read English.

We worked to minimize the amount of written instructions used in the slide show to help make it more appealing to children, and to not lose visitor attention with text. We did not include the specific scientific terms such as “angular momentum” because ensuring the label was comprehendible to children was a concern that was brought up beforehand through surveys and informal interviews with explainers, and conversations with the visitor research department.

The written instructions were highlighted on screen by using a black background and white text. This was not feasible for the instruction block on the start slide because too many words were present, and the black background would have taken up most of the slide.(See APPENDIX L) Additionally key words like “fast” or “slow” were highlighted by the colors green and red respectively, to make use of a very common sense comparison. This was done to make the label more accessible to visitors, especially considering the average time that is spent on reading labels is less 30 seconds.

We added a short but provoking question slide to the beginning of the instructions: “Can you do this?” With this slide we were trying to achieve two goals. First, we hoped to encourage

children to correctly use the exhibit. Phrasing the question in a provocative way would hopefully challenge the children to finish watching the instructions and then try to apply them. Second, this slide added a striking contrast by using black for the background color instead of the white background used in the rest of the slides. The transition to the question slide was eye-catching because it contrasted with the other slides dramatically. We were able to add this slide which did not include explicit instructions, while keeping the slide show under our goal of 30 seconds. The total view time of one loop through the slide show added up to 25 seconds.

3.2.1.2 Designing the Slide Show Label: Arch Bridge Specifics

We made the decision not design a slide show for the Arch Bridge exhibit because of a number of limiting factors. Our experience from testing the prototypes for Turntable implied that a video visibly had a more dramatic effect on the visitors' behavior than a slide show. Although no data had been analyzed at this point, it appeared to us through general observations that the constant motion of a video was more attractive to the visitors than a slide show. We therefore hoped to examine this hypothesis further by creating a video for Arch Bridge.

Also, the setup of Arch Bridge is very open (See Figure 13) and visitors can approach it from several different directions. This, we believed, could limit the success of a screen as small as the one we used for showing the slide show instructions on Turntable. Turntable may be better suited for the slide show because there is only one opening through which the visitors enter the exhibit, meaning visitors have an opportunity to view the slide show while standing in line. (See Figure 12) Changing the size of the slide show screen could result in a more successful outcome, however the sample would be skewed, and comparison to the trends that we identified with Turntable would not be possible. Our main concern was the limited time due to the seven week deadline on the project, which would not allow us to extensively analyze three samples for a second exhibit. We therefore chose to limit our work to create a video label for Arch Bridge, which enabled us to thoroughly examine and evaluate the gathered data.

3.2.2 Designing the Video Label

Our second set of visual instructions for the exhibits we chose was a video label that illustrated proper use of the chosen exhibits, and in Turntable's case provided a connection between the science behind Turntable and real life. The video for Turntable consisted of clips that show an explainer demonstrating the correct use of Turntable, and give an example of how

the demonstrated concept applies in real life. Showing a real life example of that can be easily related to angular momentum was a very important addition to the video because it provided a way to make the mechanical concept more accessible and, easier to remember for children. Seeing an example can also help to raise awareness about how the science behind Turntable and even science in general, is visible in everyday life.

Similar to when designing the slide show, we did not expect to get a longer attention span than 30 seconds for our video. Many of the decisions during the designing phase were influenced by this limitation. Mainly the length of the clips demonstrating correct use, and the real life application had to be cut down depending on the length of the text instructions needed to explain the correct use. To decide how long the written instructions should be displayed, we considered the amount of words on the screen, and how long it would take a child to read it at a leisurely pace. To approximate this, we allowed double the time that it took members of our group to read the instructions, and rounded up a second. Written instructions that introduced new key stages were highlighted by using a plain black background against a basic white colored font that was centered on screen. Text that explained the events in each clip were emphasized by using a black bar as background, which separated the instructions from the clip itself. This ensured that the font was more visible to visitors than ordinary subtitles, which are traditionally place over the image itself. Additionally, key words were highlighted by using colors such as red and green, which were easily distinguishable from the usual white colored text.

We utilized basic symbols to illustrate important connections and transitions when possible. For example an arrow was used to show that a change in position is required to control speed, or an "=" to explain what a certain action will result in (arms and leg in = faster). This makes sure that the instructions were easy to read and important connections were comprehensible to children of our target audience. The explanations and instructions in the video were phrased very carefully, to consider our target audience. We phrased instructions simply so that they were easy to read and understand, while at the same time encouraging children to duplicate the demonstrated behavior. For example phrases like "Try this" were used in place of something bulky like "can you repeat what the man in the video was doing?"

To produce a serious looking video that encourages the desired behavior, we did not make use of impressive transitions but rather utilized basic fading from one clip to another. This

made sure the effects in the video did not distract from the video content, and focused on encouraging children to follow the presented instructions.

Similar to the slide show, the video contained an instructional section that demonstrated the correct use. However, unlike the slideshow, the video also included a piece that identified a real life application of the scientific concept. To design the "How To" part, we first identified the key stages that a correct interaction should include. We then decided who of the explainers should demonstrate the correct use in our video. This was very important because we needed to make sure that the children could relate to the example we were giving them, and not get the impression that the exhibit is designed for a particular age group or gender. Explainers proved very suitable to demonstrate the correct use because they were available on gallery when the children were watching the video. Other important factors included age and appearance in the video. Here it was important to consider what known problems the video should be aimed at fixing. For example if it is known that interaction with an exhibit is more successful for children that ask adults for help, then including a child and an adult in the video (rather than a child alone) would be a good choice.

The real life application also had to be chosen carefully, because the example had to be easily accessible to children of our target audience, and also attract attention. It therefore could not include complicated or abstract examples, but instead be centered around applications that children have seen before, but have most likely never associated with science. For example demonstrating the concept of the conservation of angular momentum should not be done using something mechanical like a flywheel, but rather an ice skater, which is easy to relate to for children as they can easily and correctly identify the ice skater, and therefore are more likely to remember it. The real life tie should also be able to be recognized quickly, because the clip was relatively short and it was important that the children could grasp the example in that short period of time.

To obtain the footage that we used to create the two sections, we filmed both the instructional part and the real life application separately. We used the exhibit itself, including the surroundings, to illustrate correct use. This ensured that children could easily relate video to what the interaction with the exhibit should look like. To record the video, we used equipment that the museum provided us with: a Sony DCR-HC32E PAL camcorder and the fluid-head

tripod VT-438 from Vanguard. The tripod allowed us to film without any disturbing motions caused by moving the camera.

We then used Adobe Premiere Elements 2.0 to edit the video clips and stream them together. The museum's multimedia team helped us out when we needed to accomplish a task that our version of Adobe Premiere could not perform. For example importing the movie from the camera into Premiere Elements, or exporting the movie to the correct format was not possible in Premiere Elements and a copy of Adobe Professional edition was required. We created multiple versions of each video instruction set which were pre tested to obtain some feedback from explainers, visitor research staff, and the project advisors before we prepared the video to be placed on gallery.

3.2.2.1 Designing the Video Label: Turntable Specifics

The first step of designing the video label for Turntable was to identify the problems we wanted to address with the video label. For this we utilized the data from the explainer survey for Turntable. (See APPENDIX M) We outlined their answers and then grouped similar answers together to create a summary of the results. We then used the results summary to help orient ourselves when deciding upon the content for the video.

We were able to use the key stages of an interaction that we had identified earlier for the slide show label in the video as well, because the ideal visitor interaction with Turntable remained constant between prototypes. The three stages we had identified consisted of: starting off slowly while leaning back, leaning in to speed up, and leaning back out to slow down. The video enabled us to actually show the transition from leaning out to leaning in, rather than showing abstract images that represented a person leaning out, and leaning in. This helped to improve the clarity of the instruction set, because the children see the correct usage in motion and can therefore easily relate to it.

We were given footage from a previous experiment to test the effects of video labeling from Robin Meisner, Dr. Alexandra Burch and Emily Bick. The videos included an explainer demonstrating the correct use of Turntable, in several slightly different methods. The clips contained multiple versions of each method, illustrating how to change the position of your weight (use your whole body, only arms or only one leg.) on Turntable to control your speed.

Robin Meisner also advised us to use simple wording in our video, to encourage use by children. For example, she had noticed a trend during her research that children were not able to remember and understand the meaning of the instruction "Weight in = fast, Weight out = slow". Instead, the children were able to relate to more simple terms such as "Bum in = fast, Bum out =slow" and were able to restate them during the interviews. We implemented this advice when designing our video label, and decided to use the terms "Bum in" and "Bum out" as well. (See APPENDIX N)

The next step was to identify an ideal real life application of the demonstrated concept. The conservation of angular momentum is occasionally illustrated in college physics classes by using a spinning stool. A person sits on a spinning stool and holds additional weights in her/his hands. The subject can control the speed of rotation by moving the weight further away from the axis of rotation (his body) or pulling the weight towards himself. However, this example is not a real life application that we would have been able to use, because it more closely represents a restatement of the concept. Instead we used a video of a figure skater performing a "corkscrew spin". Here the skater controls the speed of rotation by pulling her arms and leg towards herself and therefore gathers speed. This example is easy to understand and relate to for a child, and it makes use of the demonstrated scientific principle in a very clear way. We were able to film a thirteen year old girl performing the spin, which is near the top of our age range for the Launch Pad. We hoped to improve the success of the video label because children of our target audience should be able to associate themselves with a girl of about their age more easily. The filming was conducted at a local ice rink in London, the Lee Valley Ice Centre.

3.2.2.2 Designing the Video Label: Arch Bridge Specifics

Before producing the video label for Arch Bridge, we again identified what problems we wanted to remedy with our video through surveying the explainers (See APPENDIX O) and interviewing the visitor research department and the Launch Pad team informally. We then followed the same procedure we had when creating the video label for Turntable.

The exhibit's use is being demonstrated by an explainer and a teenager. This addresses mainly one problem that we had identified beforehand. Children tend to interact more successfully with the Arch Bridge (i.e. building a better bridge) when they ask adults for help. The video shows the teenager failing at his first attempt to build the bridge and then written instruction encourages the children ask for help. An explainer joins him in building the bridge

and they both finish the work successfully. This also encourages group work and leads to a more socially interactive experience for the visitors. Using a teenager of age fourteen has the advantage that children can identify themselves with the person demonstrating the correct use, because he also falls into the Launch Pad age range.

We identified the key stages that the video should contain in order to address the problems we recognized during our surveys: An existing bridge should be taken apart to encourage the children to build their own bridge and understand the demonstrated physics; The process of building the bridge in order to give an example for correct use; The finished bridge should be tested by walking over it or standing on it to show that the bridge is stable and can hold the child as well as an adult.

We decided to make use of fast forwarding for the building process in the video, because it can be lengthy and not every step is needed to guarantee understanding of the procedure. We considered the same attention span for this video label and cut the length of the video to exactly thirty seconds as before.

The end of the video contains a clip where the teenager and the explainer stand on top of the bridge and cheer about their work. (See APPENDIX P) We included this scene to encourage children to test the bridge that they have built. This is an important stage because often times a visitor will take the time to construct a bridge when using the exhibit, but will then leave without walking across it.

For the Arch Bridge video label, we decided to not include a real life application for several reasons. First, the building process is fairly lengthy as already mentioned and the goal was to not outrun the thirty second limit. Therefore we would have had to cut time for different scenes which was not ideal. Second, the completed bridge itself is a demonstration of the real life connection because it represents a real bridge and the forces that hold bridges in place.

3.2.3 Placing the Labels on Gallery

When placing the labels on gallery our biggest concerns were about visitor safety and following the museum guidelines on risk analysis. We also had to consider how to provide electricity to our video and slide show labels, which was challenging at times. There are very few free power points in the Launch Pad gallery, because it is designed for children and unused power plugs can present a safety hazard. Therefore the choice of placement was limited, and we

had to set up the prototypes in one specific location for each exhibit, without much opportunity to relocate them during the testing period.

Figure 15: Philips Picture Frame, Front

Figure 14: Philips Picture Frame, Back

We used the equipment that the museum provided us with to display the slide show and the video labels. The slide show was shown on a Philips 7FF1AW electronic picture frame (See Figure 15 and Figure 14). The frame displays uploaded JPEG images for a set time varying between five seconds and one week. Its display has a diagonal span of seven inches and a resolution of 720 x 480 pixels. The video was uploaded to a BLADE computer (See Figure 16) and displayed on an AG Neovo monitor that has a diagonal span of seventeen inches.

We built a basic housing for the picture frame to protect the hardware and improve the appearance of our prototype, and not distract from the content of the label itself. For this we worked together with the museum's workshops. We improved the stability by using metal plates to support the housing and foam to cover any sharp edges. The screen we used to display the video had a steady base and a plastic cover to protect the display and did not need any housing for temporary testing. The picture frame housing and the monitor were installed on a heavy table on respective testing days. We used a black piece of fabric to cover the table to

Figure 16: Blade Computer

improve the appearance and black tape to cover edges.

The museum has very strict regulation about objects that are installed on gallery to prevent possible hazards and guarantee the safety of the visitors. To gain permission to test the video labels, we needed to make sure that our prototype were risk assessed by authorized museum stuff every morning before visitors entered the Launch Pad. The risk assessment process (APPENDIX R) ensures that there are no tripping hazards or sharp edges where visitors could hurt themselves. It also verifies that a prototype is not a possible electrocution hazard or could cause other threats to visitor safety.

For a quick summary please refer to APPENDIX Q.

3.3 Evaluating Visual Instruction Effectiveness

After implementing the video instructions, our group again had to survey visitor interaction with the exhibits, using a method that was similar to how we originally gathered data. We did not survey the explainers a second time, because they did not have enough time working with our labels to fill out the survey accurately. Instead we chose to informally interview them, to get their feedback on how effective the visual labels were, and what general observations they had noticed while working in the Launch Pad. These general observations were added to our own thoughts and observations about how the visual labels were performing, to be analyzed and supported with our collected data.

3.3.1 Observing Museum Visitors

For each set of visual instructions that were added to our two exhibits, a set of visitor observation data was collected. The observation was done in the same method as before any visual instructions were added, using the same pre-coded forms and observation form keys as before. In order to ensure that the observation data from before visual instructions and the observation data from after visual instructions could be compared, it was important that no changes were made to the method of observing visitors.

3.3.2 Interviewing Museum Visitors

For each set of visual instructions that were added to the Turntable exhibit, a set of visitor interview data was also collected (See APPENDIX S and APPENDIX T), which was coupled with the observation data like before. Our method of choosing which visitors to survey remained

the same, we approached every third child we observed using the Turntable, so that we could obtain a similar amount of observations in each data set.

For the Arch Bridge exhibit, we chose not to conduct interviews on either the before or after data, because as mentioned previously, observing behaviors for Arch Bridge is more straightforward than Turntable because of the set up of the exhibit. This means that we were able to base our analysis of Arch Bridge's instructions only on observed behaviors.

3.3.3 Coding Interview Data

The first step towards analyzing the interview forms was to create a code for the responses. Interviews contain a lot of important data, however they are not easy to analyze. They are comprised of both open and close ended questions and result in qualitative data that cannot be easily quantified. Coding allows one to start quantifying that qualitative data by putting all the responses into one defined and restricted language. Coding also allows one to remove biases and feelings and make answers concrete and objective. The code applied to the responses allows the data to be easily compared and analyzed later. It is very hard to compare responses from children of different ages and backgrounds, however by coding their responses one can understand the basic idea the child was trying to get across no matter what words they used[43].

The code we created separated the responses into 3 or 4 categories and each category was divided into successful and unsuccessful to make the analysis step easier. A separate coding sheet was made for each type of label tested for each exhibit. These sheets can be found in appendices. (See APPENDIX U, APPENDIX V and APPENDIX W) These codes represent all the possible responses, and are organized by degrees of understanding. Each response on each interview was not coded separately, rather the interview was coded as a whole taking into consideration all of the responses from one child.

For interviews one cannot simply say in most cases that the visitor did or did not understand the exhibit or its concept. Most visitors will understand parts of the concept but not others or will be able to use the exhibit correctly but have a hard time conveying the concept in words. Looking at degrees of understanding also helped support our observations where we

[43] *How to Conduct Your Own Survey*, Priscilla Salant, Copyright 1994, Published by John Wiley and Son

witnessed conflicting behaviors and it was not clear whether or not the visitor understood what they were doing or used it correctly by accident or by mimicking a previous visitor.

3.3.4 Analyzing Data

To support our hypothesis that video and slide show labels would improve visitor understanding of exhibits such as Turntable and Arch Bridge and their concepts, we made use of inferential statistics where possible. We were able to use mathematical analysis because our samples were drawn randomly to prevent biased sampling and independent from each other. To test for statistical significance, we performed a two sample test, comparing the data from before any change was made to Turntable, to the data obtained after the slide show or video was implemented. The statistical significance test told us how likely it is that the pattern present in the collected data is also true for a larger population, in this case the visitors of the museum as a whole[44].

Most of the observation data collected consists of dichotomous variables, yes or no questions for example. We took the data from the observation and compared the mean value of a variable for the control data to the same variables' mean value in the video or slide show category. To do this, we formulated a non-directional alternate hypothesis based on whether we see an increase or decrease in the mean values. Then we used a chi-squared test to see if the null hypothesis could be rejected statistically for a significance level of 0.05 if the values where larger then five, else we used the Fisher Exact Test.[45] Typically the chi-squared test and the Fisher Exact Test are used in similar social science studies to compare the mean of two independent samples, where the variable is dichotomous and the samples require a non-parametric test.[46] We tried to include the statistical test whenever possible during our analysis. But when our sample data was not sufficient to prove a statistical significant test, we did not always mention the results of the statistical test.

Some problems that we anticipated involve visitors interacting with exhibit instructions differently than we had planned for. For example, although ideally each visitor who approaches an exhibit reads the instructions, uses the exhibit correctly, and understands what the exhibit was based, that was rarely the case. Because our project was based on studying exactly how visitors

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[44] David de Vaus, *Surveys in Social Research* 5th edition (Routledge, 2001)
[45] Richard Lowry, *2x2 Contingency* Table, http://faculty.vassar.edu/lowry/tab2x2.html
[46] GraphPad Software, Inc., *How to choose a statistical test* http://www.graphpad.com/www/book/choose.htm

interact with the instructions we needed to be careful to observe what the visitors actually did with the instructions, and then ask them specifically on the survey if they read or looked at the instructions. This was important to know when we had to analyze the data to figure out if the video or slide show instructions attracted more attention that regular text labels did previously.

4.0 DATA AND ANALYSIS

Throughout a three week period, data was collected on two separate Launch Pad exhibits, the Turntable, and the Arch Bridge. For each exhibit data was obtained on both school days and holiday days when families would be present in the museum. With both exhibits we tested, we aimed to investigate the impact of visual instructions on visitor behavior. Here we will present the most important and obvious changes that occurred when studying visitor behavior, both positive and negative, as well as our thoughts and ideas as to why these changes occurred. We will also discuss how we believe visitors' behavior and understanding of the exhibit is affected by visual labels, making use of information gathered through visitor research and general observations. At Turntable and Arch Bridge, observation data was collected whilst additional interview data was also collected at Turntable to enable us to understand the impact on visitor understanding of the label at this exhibit.

The approach of using observation data backed up by interviews with visitors has allowed us to extend our research beyond simply stating what patterns we observed, but to also discuss the possibility of being able to convey more than just instructions to visitors through the use of visuals. By making use of the interview data we will also analyze how visitors respond to a real life connection between the science of an interactive exhibit and real life. This allows us to draw some preliminary conclusions about the possibility of using visual instructions to make an interactive exhibit more educational, while preserving the excitement that draws visitors to interactive galleries in the first place.

4.1 Turntable

For Turntable, data was gathered using observation coupled with interviewing so that we could formulate theories based on our observations, and then ideally be able to back up our hypothesis with qualitative data obtained through the visitor interviews. Prior to gathering the observation and interview data we divided the data sets into 6 different categories, first the data was split up into family group data and school group data, then was further split into control (text label), slide show, and video. Family data was obtained on weekend days as well as days that fell on half-term, or the UK equivalent of school break. School group data was gathered on weekdays when school was normally in session. School group observations and interviews were

only conducted on days that were either Key Stage 2 (KS2) or Key Stage 3 (KS3). KS2 days include classes with ages 8 – 11, and KS3 days are intended for ages 12 – 15. During a period of nearly two weeks surveying was conducted sporadically to obtain a total of 79 interviews and 397 observations of visitors to the Turntable aged 8-14. Of those observed, half (48.9%) were female, and the average age of the visitors observed was 10.7 years, based only on our age estimations.

4.1.1 Explainer Survey Analysis for Turntable

An explainer survey was conducted for Turntable to get a general preliminary idea of how popular the exhibit is with visitors, how well its text instructions are performing and what the explainers would add to or change about the text label if given the opportunity. The survey was set up in the explainer break room, from Wednesday, May 24th to Thursday, June 1st. We received 16 responses to the survey, which were analyzed to find the averages from the numerical questions. We also compiled a list of common responses to the open ended questions, to help with pointing out some of the flaws with the current instruction sets. (See APPENDIX M) The results from the explainer survey clearly identified Turntable as a target exhibit for video instructions, with explainers identifying that this is a popular exhibit that is often misused and not well understood by visitors. The results that we obtained were very consistent, indicating that the explainers strongly agree on how Turntable is viewed by visitors. For example, the first question of the survey asked the explainers to rate how popular with visitors Turntable is. For reference the scale of each question was from 1 to 5, with five being the most positive answer. All of the results that we received either had a 5 or a 4 as an answer. A similar trend occurred with many of the numerical evaluation questions on the survey. When asked to rate how successful Turntable's text instruction set is, the explainers that filled out the survey all responded with either a 1 or a 2, making the average a 1.5 out of a possible high score of 5.0.

4.1.2 Quantitative Analysis for Turntable

The quantitative analysis of the observation data collected for Turntable helped to identify some important trends that highlight both the successes and shortcomings involved with using visual labels in an interactive museum gallery. For both the video label and the slide show label there were important changes that occurred in the sampled population's behavior which can be used to identify the strengths and possible weaknesses of utilizing visual labels. The most

important and obvious changes have been presented, with explanations detailing why we believe such changes in behavior patterns might have occurred. We have also presented the inferential statistics with many of the behavior changes, helping to prove the validity of the changes where possible.

When studying interactions with the Turntable exhibit, we analyzed the behavior of two different groups, family groups and school groups. As expected the differences in observed behavior between the two groups was very different regardless of which type of label was present, a factor that may be attributable to the differences in child to adult ratio. (Evidence from the museum visitor profile suggests that the family groups visit in a 1:1 ratio of children to adults, however school groups are only required to have a ratio of 8 children per adult) Family groups seemed to be overall the most successful at interacting with Turntable, and accordingly they also proved to be the most successful at learning from the visual instructions when provided. (See Figure 17)

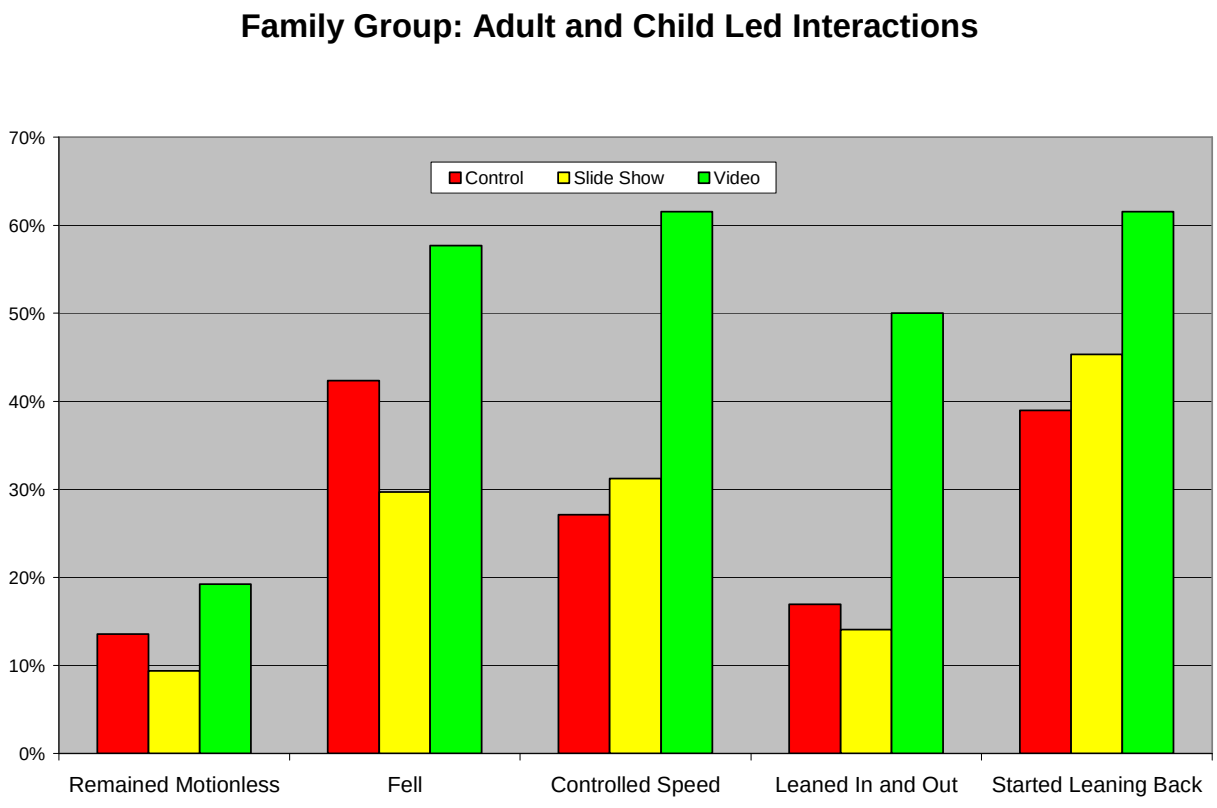

Figure 17: Family Group, Adult and Child Led Interactions

One of the major observed differences with school groups, that most likely had a dramatic effect on differences in behavior patterns was that school groups tend to all pile into the ring of the Turntable rather than form lines where they can see the video or the slide show, or the text label. Because family groups are not as large as a school group, and are not as well acquainted with the other visitors standing in line for the Turntable they usually form a line, meaning they get the opportunity to see the video before they enter the exhibit.

4.1.2.1 Family Group Data for Turntable

Family groups responded best overall to the visual labels, especially the addition of the video label to the Turntable. One very large observed improvement occurred with the "Leaned In and Out" variable that we observed. "Leaned In and Out" represents that a visitor fully experimented with the concept of leaning as the method to control speed while on the Turntable, and is a very reliable way to determine if they could relate the concept of speed to the position of their body on the Turntable. The criteria for marking that a visitor leaned in and out required that the visitor first be spinning, and that the effect of them leaning had an impact on the speed that they were rotating. This was important because if a visitor was not moving on the Turntable and simply leaning in and out while standing still this would not be considered a successful interaction. Before any visual instructions were implemented, the percentage of family visitors who leaned in and out on the Turntable was only around 17%, with the addition of the slide show that percentage fell to 14%, which is not much of a decrease and it can be assumed that the slide show did not affect the "Leaned in and Out" variable. When the video was added to the Turntable however the percentage of visitors who demonstrated they could lean in and out on the exhibit while spinning rose to 50%. This increase was analyzed using the chi-squared test, to help prove that the increase was a direct result of our video label and not a random sample. The chi-squared test yields a P value of .0015, indicating that our observed increase in the "Leaned In and Out" variable can be statistically verified.

Additionally, another variable we observed for, "Controlled Speed," also saw a dramatic increase with the addition of the video instructions. "Controlled Speed" means that a visitor was able to make themselves go faster or slower on the Turntable by leaning, and did not include if a visitor started and stopped themselves with their foot or had a friend push them around in circles. Although "Controlled Speed" is similar to "Leaned In and Out" it differs in the fact that the

criteria for controlled speed only required the visitor to change position once (lean out to in, or lean in to out) to observe the change in speed. Before any visual instructions, the percentage of family group visitors who controlled their speed on the Turntable was 27%. When the slide show was present this made a small leap to 31%, which is not a large enough change to draw conclusions from. However, when the video label was used the percentage of visitors who Controlled Speed rose to 62%.

Another success that we observed when testing the visual labels was the increase in the percentage of family group visitors who started their interaction by taking a leaning back position as they began to spin on the Turntable. This was an important variable to measure because one of the concepts behind a successful interaction with the Turntable is that in order to spin quickly, the visitor must start in a leaning back position and pull themselves in towards the center of the platform. Starting leaning back was also very important to measure because it provides the easiest way to start off on the Turntable. Without any visual instructions, the percentage of visitors who started leaning back was 38%. The slide show caused a small increase, where we observed a percentage of 45%. The video however had a far bigger impact, giving a percentage of 62%, which is a 24% increase over having no visual instructions. It is important to note, that many of the visitors who were marked as started leaning back may not have interacted perfectly with the Turntable after they began spinning while leaned back. Similarly, a number of visitors who did not start leaning back were still able to control their speed on the Turntable by leaning, even if they started by some other method. Each interaction must be taken only as a piece of the entire puzzle when analyzing correct interaction with the exhibit.

One important difference to note is the way that the instruction to start leaning back is presented between the three different instructional prototypes. The text label quickly mentions to start off leaning back in large bulleted text near the top. The slide show however explicitly says that starting leaning back is important, and the particular slide that gives this command is displayed for 10 seconds continuously to give visitors adequate time to read the text. Finally the video simply states to start off leaning back in white lettering on a black background for several seconds (about 3), and then quickly shows the explainer starting off in a leaned back position. The differences in the way this instruction was presented no doubt helped to affect how each group performed in this category. The video displayed the started leaning back instruction for

only a third as long as the slide show, however still recorded better results. This suggests that more visitors paid attention to the video over the slide show.

One other important change to note in the observation data for family groups on Turntable is the rise in percentage of some of the categories that we had labeled as unsuccessful interactions on our observation sheet. One of the most obvious increases in unsuccessful interactions was the rise of the percentage of visitors that fell on the Turntable when the video label was present. When observing, we defined falling as a visitor who steps off of the exhibit because they clearly lost their balance (not left the Turntable because they were bored) or fell onto the ground while they were still spinning. We did not mark down visitors who fell because they were dizzy after using the Turntable, or falling down to be overly dramatic. Often times, visitors who fell would get back on the Turntable and attempt another interaction, and some were successful. This means that visitors who fell did not necessarily stop the interaction afterwards. When no visual labels were present, the percentage of visitors who fell was 42% of the visitors that interacted. With the slide show prototype in place, the percentage of visitors who fell using the Turntable dropped to 30%. Finally after the video label was tested, 58% of the observed visitors in family groups fell when using the Turntable. We believe that this increase in visitors that fell can be attributed to several factors; one of those being how the visual label and slide show label were designed. The difference between the slide show instructions and the video instructions was most visible during the first section, when the visitors were told to start slowly leaning back. On the slide show, these instructions were displayed for a full 10 seconds, giving visitors a good chance to look at the diagram and read the text. In the video however the entire process of using the Turntable was played back at normal speed, at it can be difficult to see exactly how the explainer in the video gets himself started. Also the instruction that said “Start slowly leaning back” was only displayed for about 2 seconds. This combination seemed to result in more visitors falling because they would either lean back and have their friends push them so hard that they fell over, or they would try to get started incorrectly and fall off in the process. One example we observed was a visitor spinning the Turntable around with his hands as he stood to the side, and then trying to jump onto while it was in motion.

Another variable that we observed while studying the effect of our labels on Turntable was if an adult helped the child use the exhibit, either by providing verbal advice, or by physically spinning the exhibit for them. This allowed us to separate our analysis of the family

group data into two subsections, child led interactions, and adult led interactions. We defined an adult led interaction as someone who appears over the age of 18 verbally instructing the child in how to use the exhibit, demonstrating the use of the exhibit, or helping the child use the exhibit physically, for example pushing. Originally we had planned on being able to compare the two and be able to draw conclusions about if an interaction was more of less successful if an adult was present. Unfortunately however with the family group data collected when the video prototype testing was done, only 5 Adult Led Interactions took place, which does not provide a solid enough basis to draw accurate comparisons. We have included the data anyhow, because some conclusions can be drawn about the differences in effectiveness when the slide show was present compared to the text label. (See Figure 18 and Figure 19)

One of the most important trends to notice when comparing the adult led and child led interactions is the very noticeable difference that the video label makes with child led interactions. This seems to support an original hypothesis that children would respond to a video

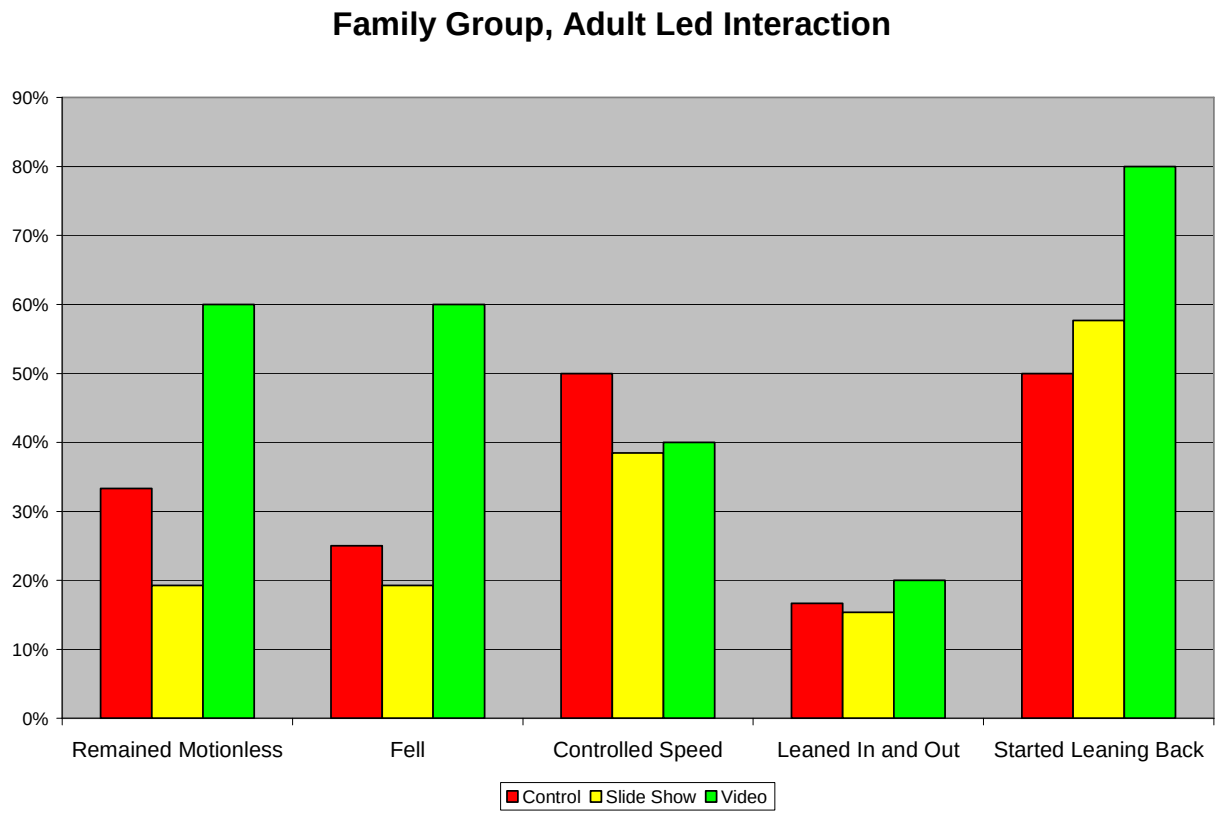

Figure 18: Family Group, Adult Led Interaction

format on a process based exhibit because the video is better at illustrating the process involved with using turntable.

Another trend that emerges is the lack of apparent behavioral changes that occurred during the testing of the slide show label, in both adult and child led interactions. For the most part it appeared that children simply did not see the slide show label as often as the video label. Based on our interview data, 15 of 37 children interviewed claimed to see the text label, 16 of 26 saw the slide show label, and 21 of 22 interviewed saw the video label. This most likely occurred for several reasons. First, the slide show was extremely small for a gallery as colorful and visually distracting as Launch Pad. Often times during our observation people would stand directly in front of the slide show label, blocking it from the sight of other visitors. Also the label was placed only about 2 ½ feet off of the ground, facing parallel to the floor. This may have made it hard for adults to see the label, which helps to explain why the slide show had no obvious effects on the adult led interaction data.

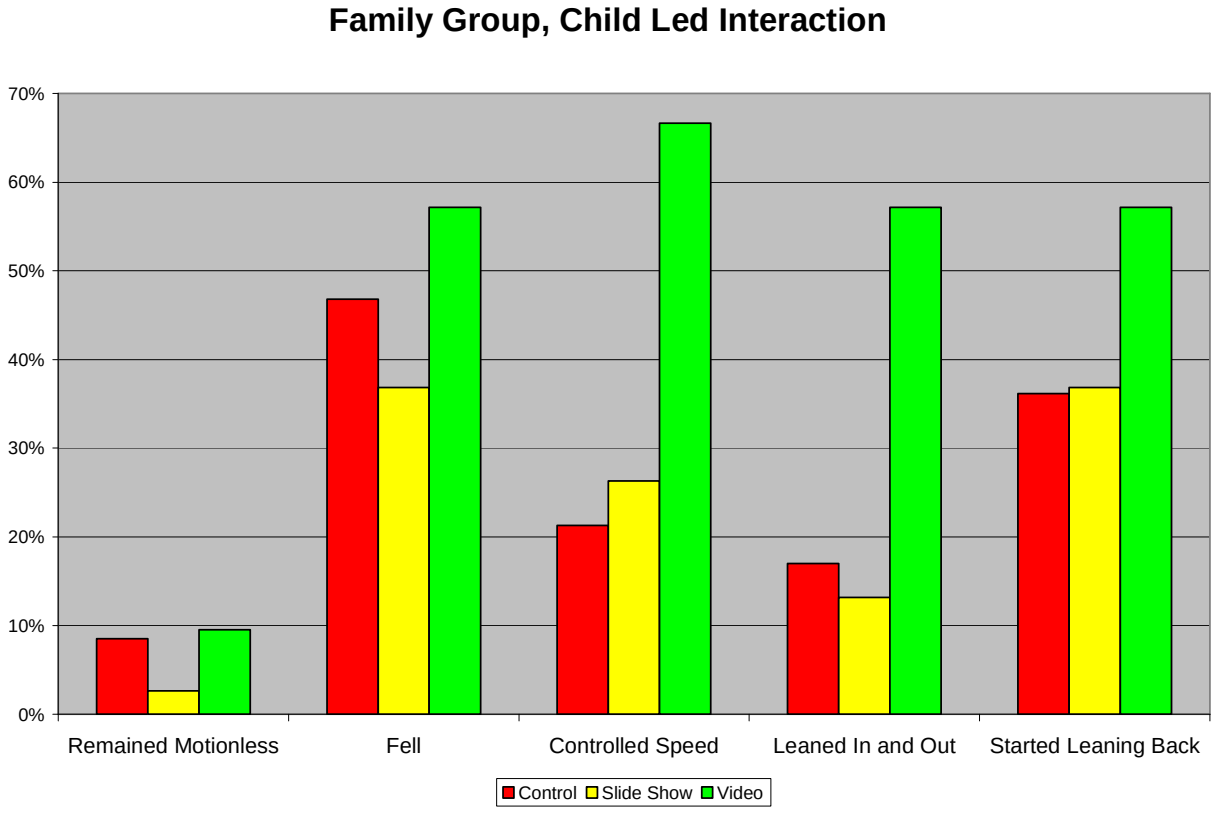

Figure 19: Family Group, Child Led Interaction

4.1.2.2 School Group Data for Turntable

For school groups, the visual labels did not have as profound an effect as they did when family groups were present. This most likely occurred for several reasons; the first is the reduced child to adult ratio that occurs when school groups are present in the Launch Pad. Typically when family groups visit the museum one parent will be present for every one child[47]. When a school group goes to the museum however they are only required to have one adult present for every 8 children that enter. This means that there is far less supervision in the Launch Pad, and less adult help and support when the children are using the Launch Pad exhibits. Also school groups may tend to see a visit to the Science Museum as a day off from learning, so rather than taking their time and using the exhibits properly they would rather just enjoy themselves. These factors we believe contributed to the decreased success of the visual labels on the Turntable.

The visual labels did however cause several observed behavioral changes that can be attributed to the partial success of the visual labels with school groups. Some of the impacts of the visual labels that we were able to observe was the increase in the amount of visitors who were able to lean in and out on the Turntable, which means that they had fully explored the effects that leaning had on speed change. Before any visual instructions were added, only 5% of the visitor interactions with the Turntable included visitors who leaned in and then back out to fully explore the concept of how leaning affects your speed on the Turntable. (See Figure 20) When the slide show was tested the percentage of visitors who leaned in and out fell to 2%. The most dramatic change was observed when the video label was present however, the percentage jumping to 29%. To aid in proving that this increase was a direct result of our video label, and not a statistical irregularity, we utilized the chi-squared test. The chi-squared test yielded a P value of <.0001, which is well below our accepted limit. This we believe can be attributed to how visitors respond to visual labels in a setting like the Launch Pad. Because the Launch Pad does not use a visual labeling system currently, and contains little electronic equipment, the video label was able to get attention easier, and even if the visitors only watched the instructions briefly, it can sometimes be enough to reinforce the proper use of the exhibit.

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[47] Elin Simonsson, *Data about Science Museum family visitors*, London, Science Museum Visitor Research Department: 2005

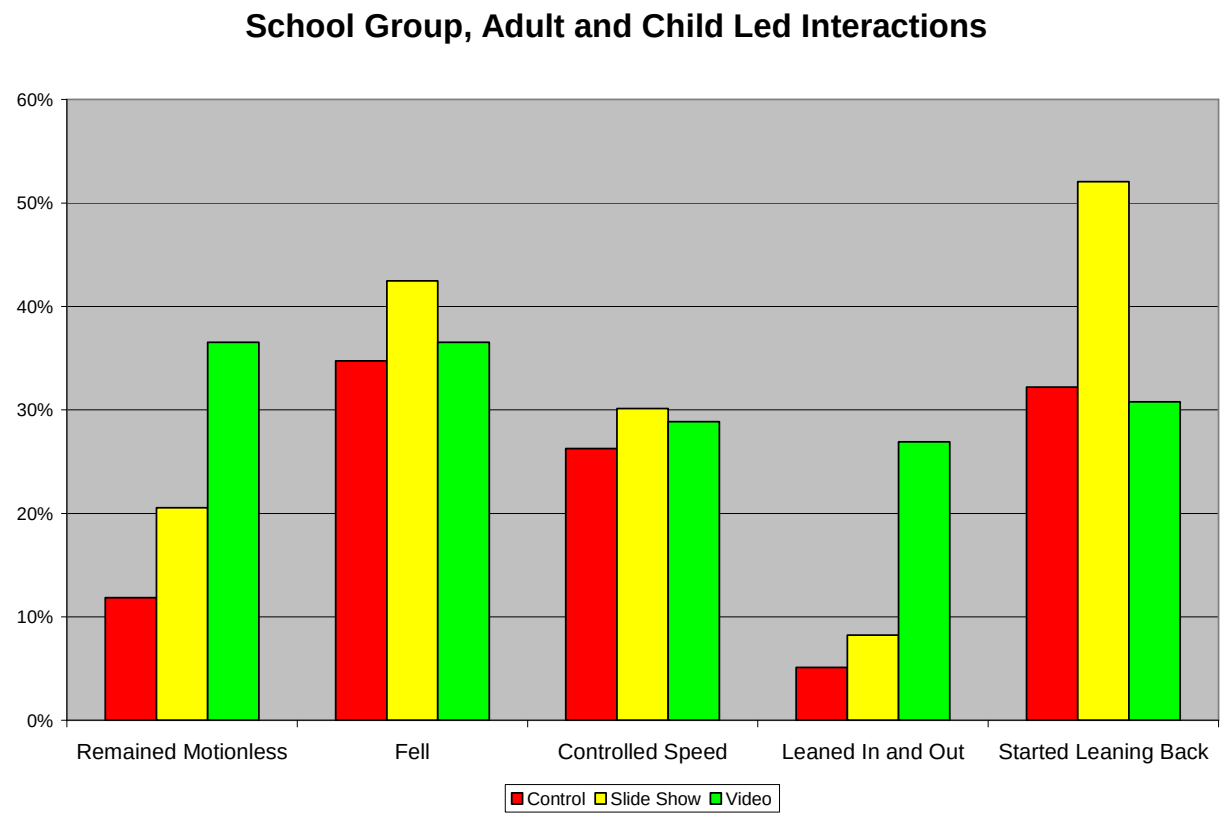


Figure 20: School Group, Adult and Child Led Interaction

At first glance, the observation data collected when school groups were present in the Launch Pad seems to highlight the success of the both the slide show and video, however in some cases it shows the visual labels as being less successful at demonstrating proper interaction than the text label alone. (See Figure 20) One reason that we collected so many different observation variables during our study was to try to figure out what the visitors were doing on the Turntable, other than using it correctly. It seems important to note that when comparing the data gathered for the video, to the data gathered from the slide show and control, that far more visitors in the video group used their feet to gather speed on the Turntable, rather than controlling their speed by leaning. There are two possible answers as to why this may have happened. The first possible explanation is that the visitors may have observed the explainer starting himself off by using his feet. Even though the explainer in the video was only using his feet so he could get himself spinning initially, and then began to control his speed correctly, perhaps young visitors may have taken the wrong message away from the video, and believed it was alright to spin themselves using their feet. The second possibility is that perhaps the classes that we observed while the video label was in place either did not see the video label as often, or did not care about using the exhibit correctly. Either explanation can help to rationalize why the

observations for the video on this dimension contain more unsuccessful interactions, and fewer successful interactions.

Just like the analysis done for the family groups, the school groups were also split into child led interactions, and adult led interactions. We have included both charts here, to provide a similar contrast about how effective each label was at conveying the correct usage of the Turntable exhibit. (See Figure 21 and Figure 22) One important trend to notice between the adult led and child led interactions is the overall increase in the percentage of successful interactions that occurs with adult led interactions when compared to child led interactions. One example occurs with the variable "Started Leaning Back". In the child led interactions the percentages ranged from around 25 – 35% between the control, slide show, and video, with no obvious improvement seen in any category. When compared to adult led interactions however the control groups has 0% of the observed visitors being recorded as started leaning back. However, both the slide show and the video show a large increase in the number of visitors that

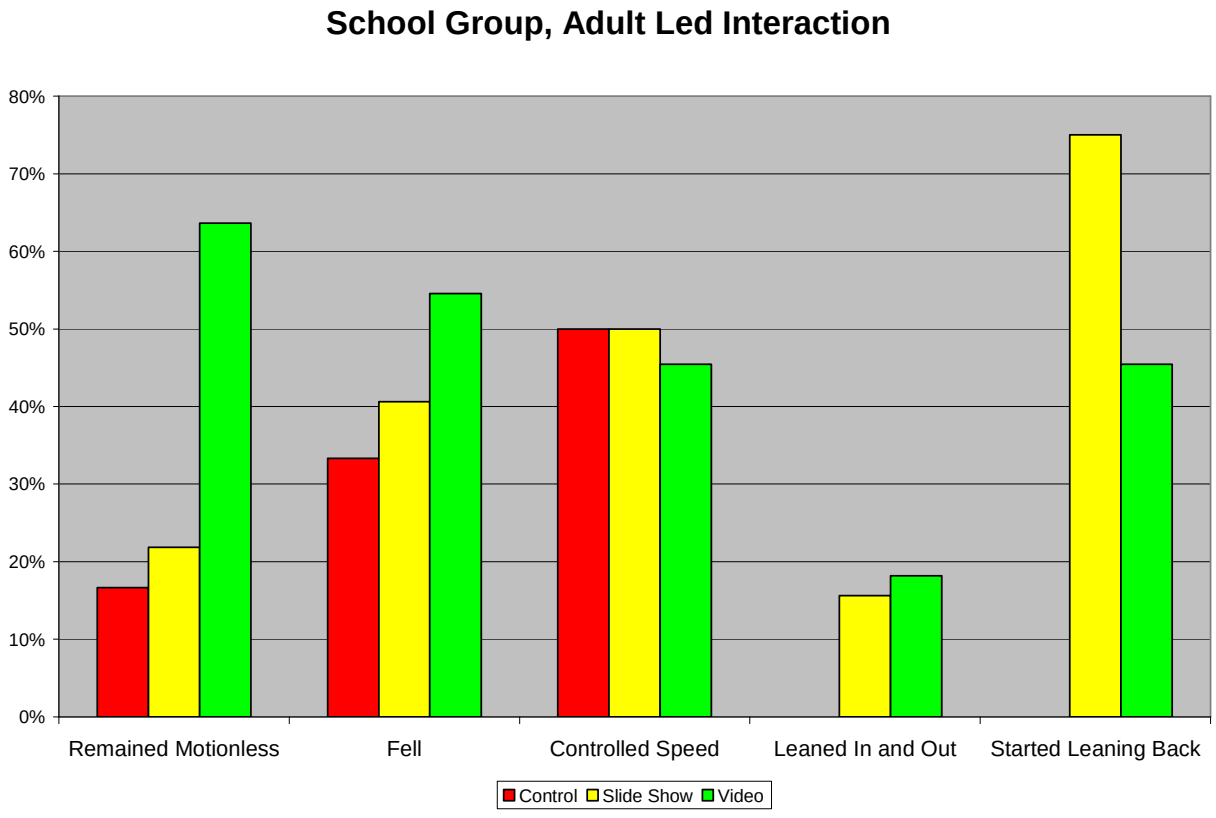


Figure 21: School Group, Adult Led Interaction

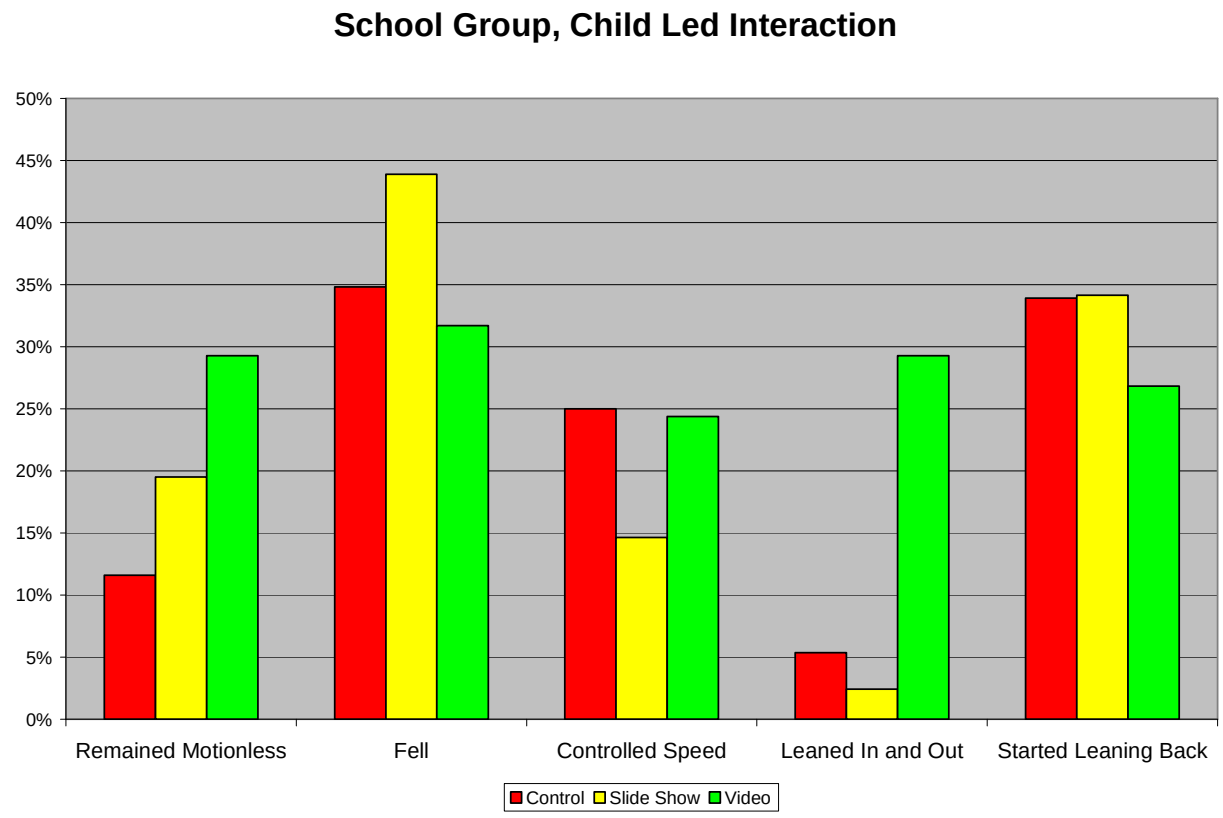


Figure 22: School Group, Child Led Interaction

started leaning back, indicating that teachers may have seen the video or in this particular case the slide show, and instructed their students in how to correctly start off on the Turntable.

4.1.2.3 Interaction Time for Turntable

One important variable that we tested for Turntable was the length of time visitors spent interacting with Turntable. Interaction time allowed us to measure if adding some sort of visual label would affect how long a visitor stayed at the exhibit. To time interactions with Turntable, we started the watch as soon as the visitor reached the spinning platform, and stopped the watch when they stepped off of the spinning platform. If visitors stepped off and on several times in one interaction, to do something not related to the exhibit such as talk with a parent, the time was paused and started again when they stepped back on. For the observation data we gathered, the average length of time for the control group was 27 seconds in length. When the slide show was tested the average interaction time was calculated at 36 seconds, which is a 9 second increase over the control group. For the video, average interaction time rose again to 40 seconds, which is a 4 second increase over the slide show and a 13 second increase over the control group. (See Figure 23 and Figure 24)

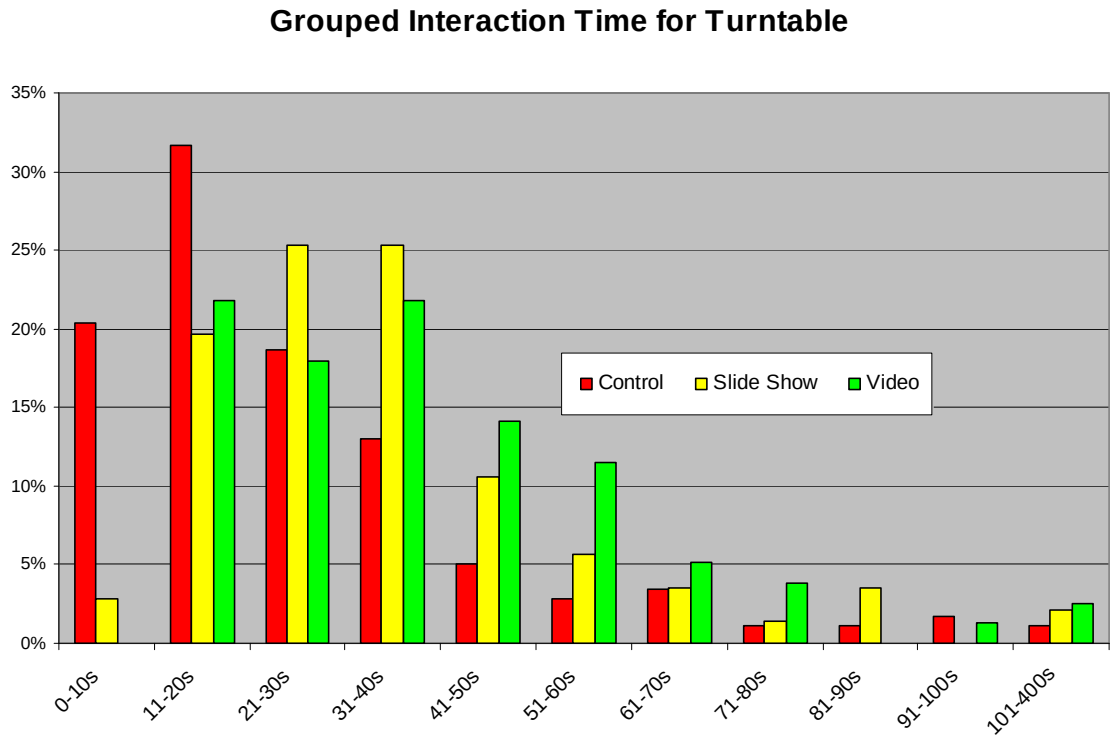


Figure 23: Grouped Interaction Time for Turntable

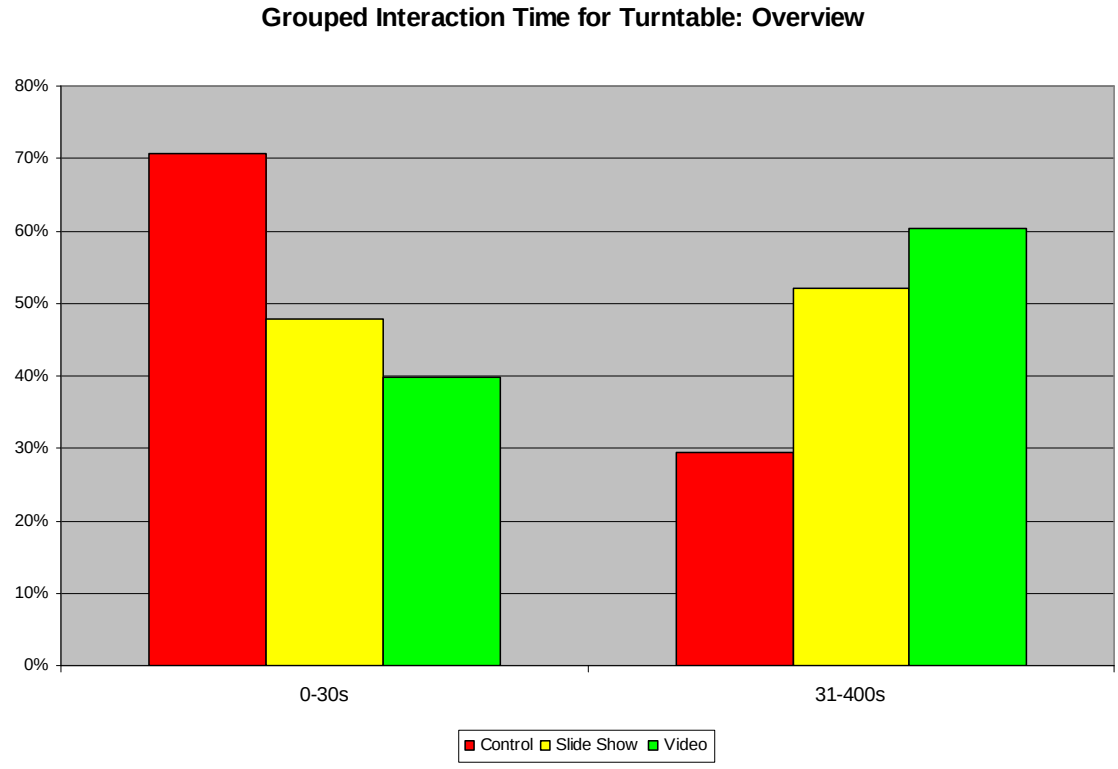


Figure 24: Grouped Interaction Time for Turntable: Overview

One of the reasons we believe that interaction time went up with the video and slide show is because visitors would extend their interaction to include both successful and unsuccessful elements. Often times a visitor would begin by using the Turntable unsuccessfully, for example simply holding on and spinning as fast as possible, and then another visitor would point out to them how to correctly use the exhibit after he or she had watched the visual label. Then typically the subject under observation would change their behavior and begin to interact with the Turntable more successfully based on what they had been told. This resulted in a similar number of unsuccessful interactions as compared with the control group, but also a higher percentage of interactions that included successful elements.

4.1.2.4 Barriers to Success for Turntable

Some possible barriers to success for the slide show include the placement of the prototype, the angle that the screen was placed at, and the size of the screen. The table that the slide show prototype was placed on for testing was only 2 ½ feet off of the ground, making it difficult to see for tall visitors like adults, unless they were standing back from it. Looking from a distance may have been a problem however because the size of the screen was only 7 inches diagonal, and reading the instructions on the slide show may have been difficult for adults at a distance. Furthermore, the screen had to be angled so that it was parallel to the ground, making it even more difficult to see without bending down. Also as mentioned previously the screen was easily blocked by visitors as they stood next to the entrance to the Turntable. In one case a visitor even put their coat over the screen to the slide show without realizing that she was obscuring instructions. Another possible barrier to success was the common impression that the prototype was an interactive touch screen rather than a series of preprogrammed static images. Young children would frequently touch the screen multiple times in a row trying to get the slide show to respond. Often times after they realized it was not a touch screen they gave up and stopped watching the screen. This was a problem because children were more focused on making the image on the screen change rather than reading and learning from what it was currently displaying. Also the disappointment that the slide show was not interactive may have been enough to motivate visitors to ignore the label purposefully. This theory was most likely fueled by the fact that the museum frequently uses interactive touch screens in many galleries

(however, not in Launch Pad) and other locations throughout the museum to provide information to visitors.

The video label experienced the same problem of being treated like a touch screen, however, far less frequently. We believe that this is due in part to the fact that the video is always displaying motion, while the slide show only displays images that change after several seconds.

Another barrier to success at the Turntable with the video was that it may not have described how to start off on the Turntable in enough detail for visitors to completely understand how to start themselves off. The video shows the explainer pushing off, but this is shown very quickly. Our observation data suggested that visitors found it difficult to start more frequently and therefore suggests that greater attention to this detail should have been provided. This is demonstrated by the observed increase in both "Remained Motionless" and "Fell" as stated previously.

One very important barrier to success at the Turntable using the video was that it could not be seen by anyone who was inside the Turntable area (the padded circle housing the exhibit) - this included the person currently using the exhibit. (See Figure 25) This may have caused fewer successful interactions because visitors could not refer back to the video for instructions when they were on the Turntable without losing their spot in line. The only opportunity to look at the video was in line, which meant that visitors had to remember what they had seen, and then apply it to a process they may have never done before. This may have been too much of a mental connection for young visitors to make. Also this was a problem for school groups simply because they tend to all pile into the ring of the Turntable rather than form lines where they can see the video. Because family groups are not as large as a school group, and are not as well acquainted with the other visitors standing in line for the Turntable, they usually form a line, meaning they get the opportunity to see the video before they enter the exhibit. In comparison, for Arch Bridge (See Section 4.2), the video label was placed so that visitors who were currently interacting with the exhibit could refer back to it for instructions and even visual feedback that they were building correctly. Evidence collected during observation suggests this was a more successful set up.

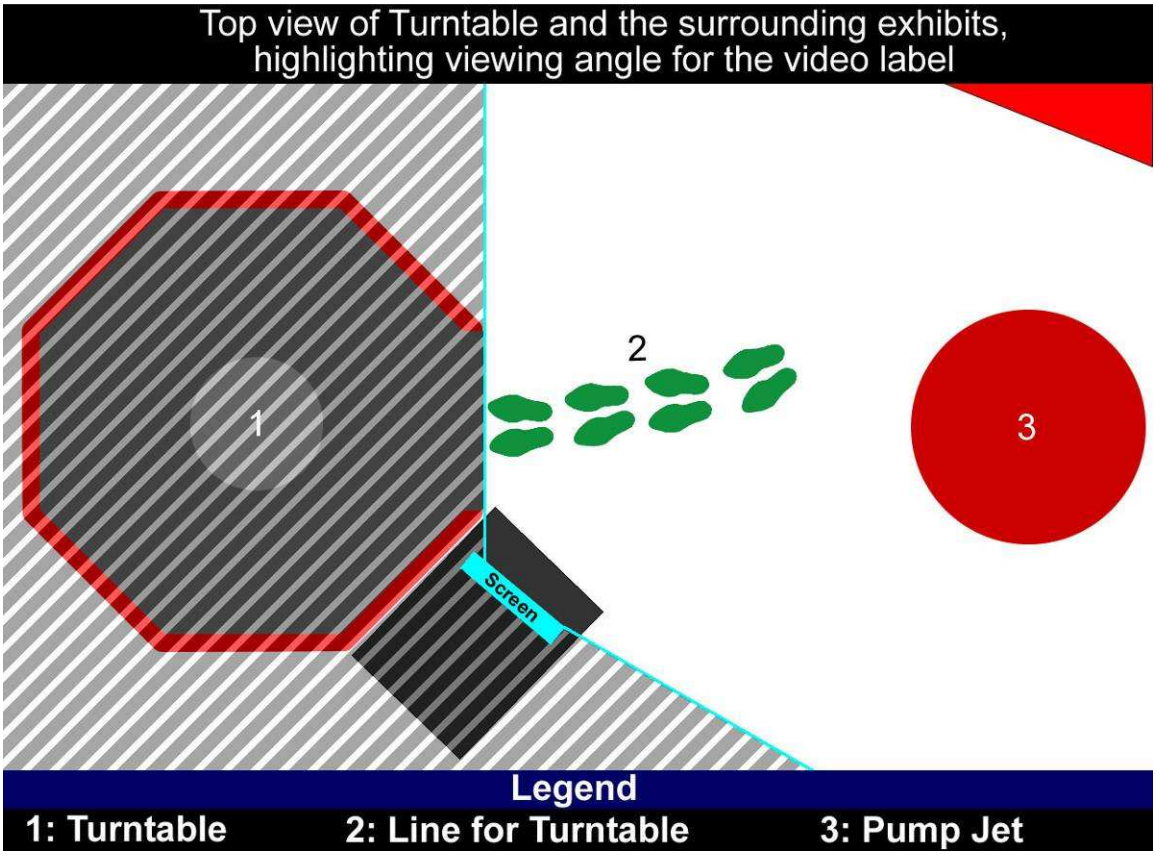


Figure 25: Top View of Turntable

4.1.3 Qualitative Analysis for Turntable

The data we collected from interviews of visitors that had used Turntable was an important part of our analysis. These interviews were carefully planned and executed. 86 interviews were collected in total. The answers we received both supported and explained our observation data. Observation allowed us to see how successful visitors used the Turntable, while interviews allowed us to see why people behaved the way we observed them, how much they understood, and if they knew how the exhibit worked. Our interviews confirmed what our observation data had suggested; out of the three labels tested in this project, the video label was most effective at getting children to use the exhibit correctly. We also saw a large increase in understanding of the concept with the video installed.

The interview questions had to be phrased in a certain way to get the information we were looking for. We had some examples from previous interviews the museum had conducted, however we had many different and possibly confusing questions that needed to be phrased correctly. To make sure our questions were phrased correctly and that we were getting the

answers we were looking for we pre-tested our questionnaires. During pre-testing we found that some questions did need reworking because they were too often misunderstood by visitors. For example, we found that many children we interviewed did not understand what we meant when we asked how they controlled their speed. We fixed this by adding a probing question that rephrased and asked how they made themselves go faster or slower. One word that needed to be changed was exhibit; we found that many children thought that word meant all of Launch Pad and not just the Turntable. We therefore had to state in each question that we were talking about the Turntable and later started showing a picture of the Turntable to the child at the beginning of each interview.

During our analysis of our observation data we saw some unexpected trends. It was only through analysis of our interview data that we were able to explain these trends. Two of these trends were that more people remained motionless and more people fell when the video was in place than when any other label was there. This corresponds to our interviews where we found more children describing the Turntable as hard to use, hard to stay on, hard to get started or stop, and hard to keep their balance when the video was installed then with the slideshow or text labels. Again we believe that this was due to the fact that the instructions simply did not give enough detail about how to get started off. This is most likely because the video did not spend a significant amount of time detailing how to start off, but rather focused on how to control speed when moving.

Our interview data also supported much of what we observed. For example, the majority of visitors interviewed told us they did not notice the text label and almost half told us they did not notice the slideshow while only one visitor interviewed stated they did not notice the video label out of 22. This corresponds to what we observed and supports our conclusion that the video label was most effective in terms of being noticed and observed by visitors. The majority of visitors interviewed also stated that the video label helped them know what to do on the Turntable while only about thirty percent of visitors stated that the text label helped that know how to use the turntable and about forty percent said the slideshow helped them. These results correspond with how many visitors noticed each type of label and the correct usage of the exhibit with each type of label in place.

One of the biggest increases we saw when comparing the interview data was the amount of visitors who were able to grasp the real life tie that the video was trying to show. The real life

tie that we chose for Turntable was an ice skater, because an ice skater uses illustrates angular momentum when she does a corkscrew spin. With the text label, a picture of an ice skater was present, however it was very difficult to make out as an ice skater. (See Figure 26) When we surveyed visitors before the addition of any visual labels we asked if they looked at the text label. If they replied positively, we then asked if they saw the picture on the text label, and if they could describe the picture on the label. The closest one boy got to getting the question correct was claiming it was a *"Ballerina"* - Boy, Age 14. The rest of the visitors surveyed did not see the text label, did not see the picture on the text label, or could not make out what it was.

Figure 26: Text Label (Surfboard) for Turntable

When we interviewed visitors about the real life connection of the ice skater displayed on the video however the results were far more pronounced. A large percentage of the visitors were able to identify the ice skater before even being asked about it, naturally referring to the skater as part of their answer. Some were even able to make the relation to what they were doing on the Turntable and what the ice skater was doing in the video.

Question: *"What do you think the Turntable is trying to show people?"*

Answer: *"How figure skaters have to stand when they skate."* –Girl, Age 11

Although the answer to the question was not completely correct, it is an example of a visitor who saw the real life tie, and believed it was important enough to mention in the interview before we had asked about it.

Question: *"Why do you think we put the ice skater in the video?"*

Answer: *"To show things are more common than we thought"* -Boy, Age 11

Beyond illustrating real life ties, the video showed great potential in teaching the successful use of the exhibit. Often times the visitors we observed may not have been physically able to use the Turntable correctly for a multitude of reasons (too crowded, couldn't get started,

started too fast) but when interviewed they could correctly relay how to control speed on the exhibit.

"I stepped onto the [Turntable], I put one foot outside the spinning platform and one in and pushed myself then put my bum in to go fast." –Boy, Age 11

One important thing to note is that the subject we interviewed used the phrase *"bum in"* which was exactly the wording used in the video to convey speeding up and slowing down. This is important because it helps to show that visitors will remember parts of a video label and can even repeat them back without being prompted. One different visitor when asked how they knew what to do when they got on the Turntable pointed out the video label, and repeated what was shown perfectly.

"Little computer that tells you what to do, tells you to put your bum in to go fast, bum out to go slower and gives example of ice skater." –Boy, Age 11

This answer also helps to show the success of the real life tie, because not only did the subject mention the exact wording that the video uses to demonstrate speed, but he also related it the example that the video provides.

4.2 Arch Bridge

For Arch Bridge, data was collected only through observation and explainer surveys. This was decided prior to picking the exhibit and was a major factor in our choice of exhibit. We decided we needed to choose an exhibit which we thought a video label could change behavior at rather than just changing understanding of the concept which would be more difficult to pick up through observation alone. To account for the fact that only visitor observations would be used to analyze Arch Bridge our pre-coded form was very detailed and allowed us room to provide detailed comments about the specifics of each visitor's interaction. We observed children using Arch Bridge for nearly two weeks, which includes the time that was necessary to pre-test our form. Similar to the method for Turntable, we grouped our samples in four sets, first separating family from school groups and then dividing each into a control (only text label) group and one that included the video instructions. Our observations were carried out over 5 consecutive days and included KS2, KS3 weekdays and a weekend to collect family group data. We obtained information on 195 interactions of which 32% of the visitors were female and the total average age estimate was around ten years. The fact that fewer girls were observed interacting with Arch

Bridge than boys could be because the exhibit may seem more appealing to boys. However, we believe the reason for this trend lies within the design of the exhibit, because the male to female ratio was consistent throughout all four data sets.

4.2.1 Explainer Survey Analysis for Arch Bridge

Similar to our procedure for designing a video label for Turntable, we conducted an explainer survey for Arch Bridge. This survey was aimed at understanding the explainers' perception of the current instruction set for Arch Bridge, and identifying possible problems that the video label could be directed to remedy. The survey was set up for one week and in that time we received 11 responses to the survey, which were analyzed to find the averages for the numerical questions. Additionally, we compiled a list of common responses to the open ended questions, to help with pointing out some of the flaws with the current instruction sets. (See APPENDIX O) Responses suggested that explainers feel that this is a popular exhibit with visitors but is one where the instructions are currently inadequate. The averages identified Arch Bridge as a very popular exhibit. The first question asked how popular Arch Bridge is, and the explainers rated it as a 4.3, with 5.0 being the best possible answer. However the explainers also agreed that the instruction set is not very successful, giving it an average rating of 1.8. Also the explainers seemed to agree that Arch Bridge was relatively successful at teaching its scientific subject, giving an average score of 3.6.

The general consent of the open ended questions indicated the need of more visual instructions and a more concise description of what the visitor had to do. The explainers' feedback for the last question, which asked if the pull-out supports should be used with Arch Bridge, was ambivalent in the sense that most explainers recognized the need for supports, because children of the target audience are usually physically not able to complete the bridge alone, but also identified problems caused by the supports.

4.2.2 Quantitative Analysis for Arch Bridge

Analyzing the quantitative data that we collected for Arch Bridge was our only method for determining how effective the video label was at affecting visitor behavior, because no interviews were conducted. All numbers and figures are based on the data that we gathered using the same form for all four data sets. (See APPENDIX F) The form contains two added rows that are only for use when observing the video prototype, because they provide information on the visitor's interaction with the video label. We added these rows to keep track of visitors

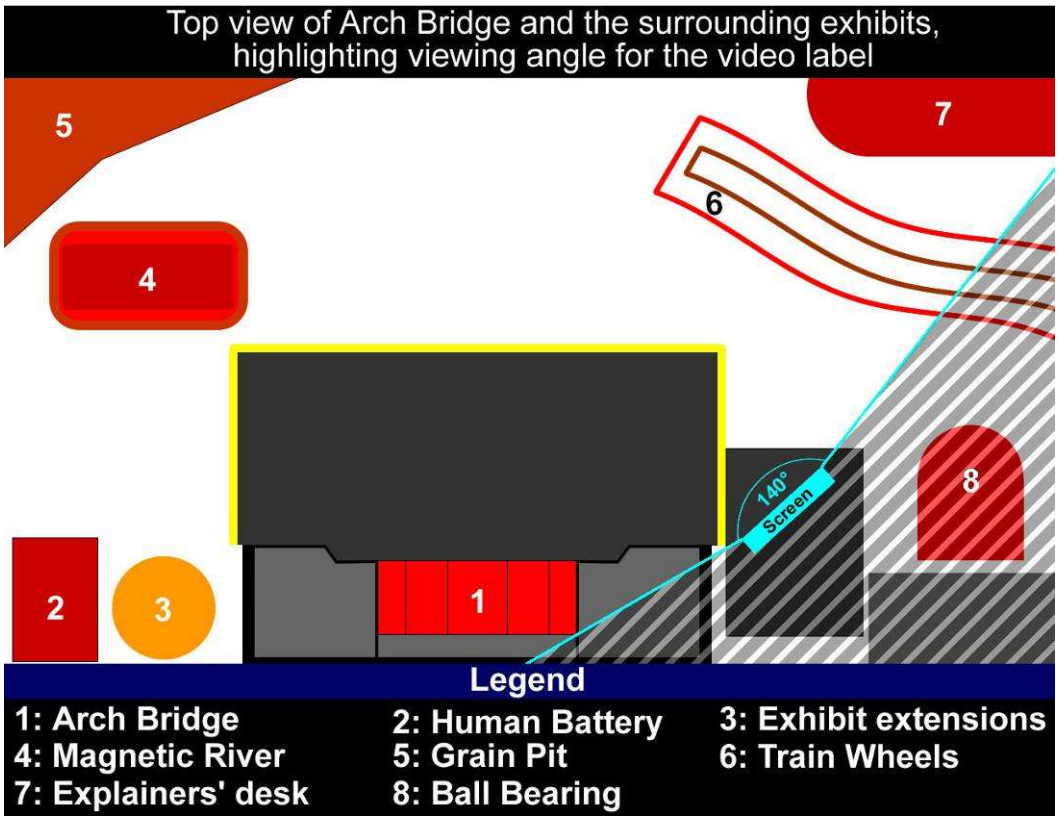


Figure 27: Top View of Arch Bridge

that clearly were watching the video, to help determine if successful interaction could be more clearly correlated with watching the video instructions. To determine if visitors were actively watching the video we looked for indicators, for example, children who were standing in front of our prototype and holding the monitor frame while looking at it, visitors that kept exchanging looks between the exhibit and the video, or visitors that instructed others and referred to the monitor. This implied that the observed data for this variable had to be considered very carefully, because it does not completely include all visitors that watched the video, only those

who we could clearly identify as watching the label. This means that we may well have excluded those who saw it from surrounding exhibits, where it was clearly visible from (See Figure 27) i.e. visitors might have watched the label from a distance and never actually approached the Arch Bridge itself, resulting in no interaction data being recorded for such visitors. However, despite this rigorous definition of this variable, nearly two thirds (64%) of all observed children watched the video and interacted with Arch Bridge before, during or after directing attention to the visual instructions. This helps to show the popularity of the video label, because such a high percentage of child visitors referred to it at some time during their interaction. This variable accounts for a variety of behaviors. Children may have started to build the bridge before or after watching the video. They also may have consulted it after they had failed their first attempt at building the bridge or watched the video without interacting with the exhibit itself.

Unlike the data collected for the Turntable, the effect that the explainers had on the Arch Bridge data was almost completely negligible. Typically, if an explainer helped a visitor by demonstrating the correct use of Arch Bridge the interaction was very successful, regardless of whether a video label was present or not. However, this success was not triggered by the text label or the video label, but rather entirely by the presence of the explainer. Therefore not addressing this influence may skew the results of our analysis. In total, out of the 197 observations, only five included the help of an explainer. In all five interactions, the child did not request the explainer's help, but rather the explainer took the initiative and instructed the visitor how to build the bridge correctly, and explained the demonstrated scientific concept. Four of these interactions fell under the category of control for family groups and one was part of the video testing for family groups. This means that filtering out all interactions including an explainer would not necessarily change the observed patterns, but instead would decrease the successful interactions for the family control group, which may be unnecessarily misleading. (See Figure 28) Therefore in our analysis of Arch Bridge we will ignore the impact of the explainers on observed visitor interaction, and treat all data like no explainers were involved.

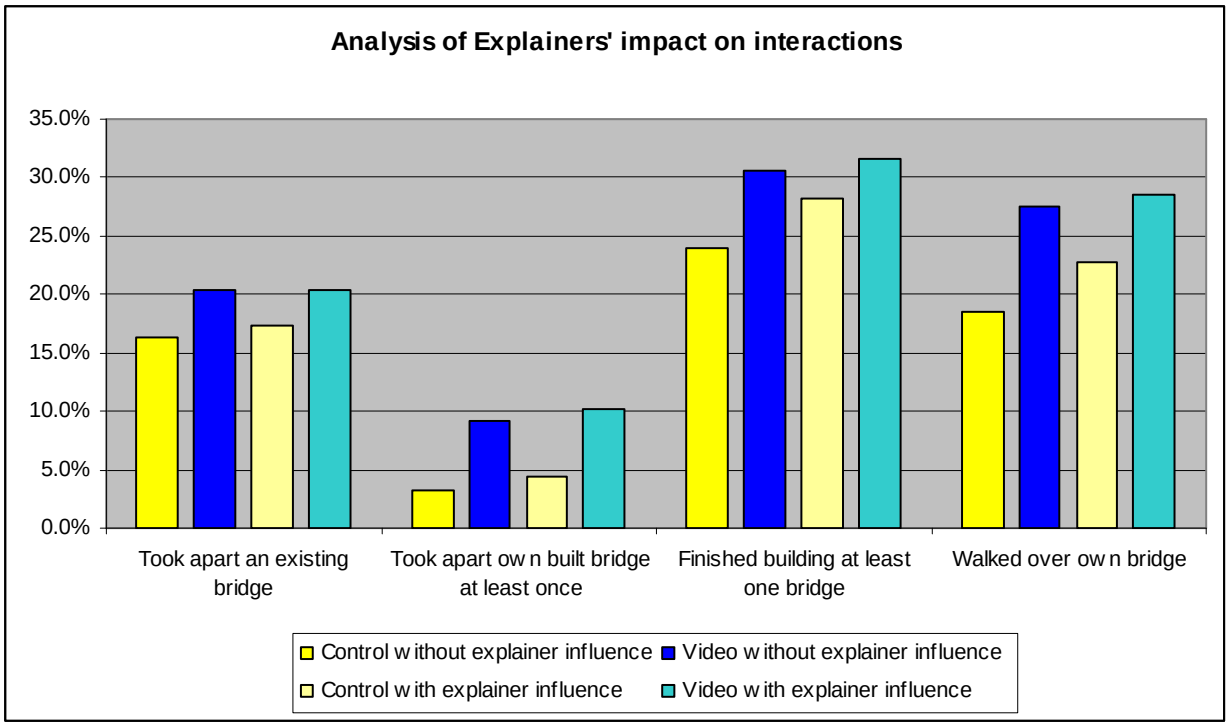


Figure 28: Analysis of Explainer Influence

4.2.2.1 Observed Effect of Video Label on Visitor Interest

The video label appeared to produce a noticeable impact on the visitors' attention and attracted them to the exhibit or the label itself. Most likely this was aided by the placement of the visual instructions, which probably contributed in drawing attention to the label and at the same time the exhibit. When we installed the prototype, children were able to notice the video label while approaching the exhibit, as well as when running over the bridge itself. (See Figure 27) During our observation for the two control samples (no video label), we noticed that many children approached the exhibit when the bridge was already assembled, and simply walked or ran over without interacting with Arch Bridge any further (e.g. they did not take apart the bridge and start assembling it again and therefore did not explore the central concept). Our observation data demonstrates the video label's impact on this behavior by decreasing the number of people that interacted with the exhibit too briefly (for less than 21 seconds) in total. (See Figure 29) One specific example is that 42% of the visitors who interacted with the Arch Bridge when no video was installed remained at the exhibit for less than 21 seconds. However, after the video was installed only 15% of the visitors did not notice the label, and had interaction times below 21 seconds. The chi-squared test yields a P-value of less than 0.0001 and therefore implies that the pattern is not randomly generated but instead is due to the presence of the video label. This

pattern helps to show how the video label helps to lengthen interaction times by increasing the amount of time that visitors spend looking at the visual instructions. Similarly, the percentage of visitors that simply walked over an existing bridge and did not interact with the exhibit any further decreased from previously 23% to 14 % when the video label was installed. However, this change was not extensive enough to be validated statistically.

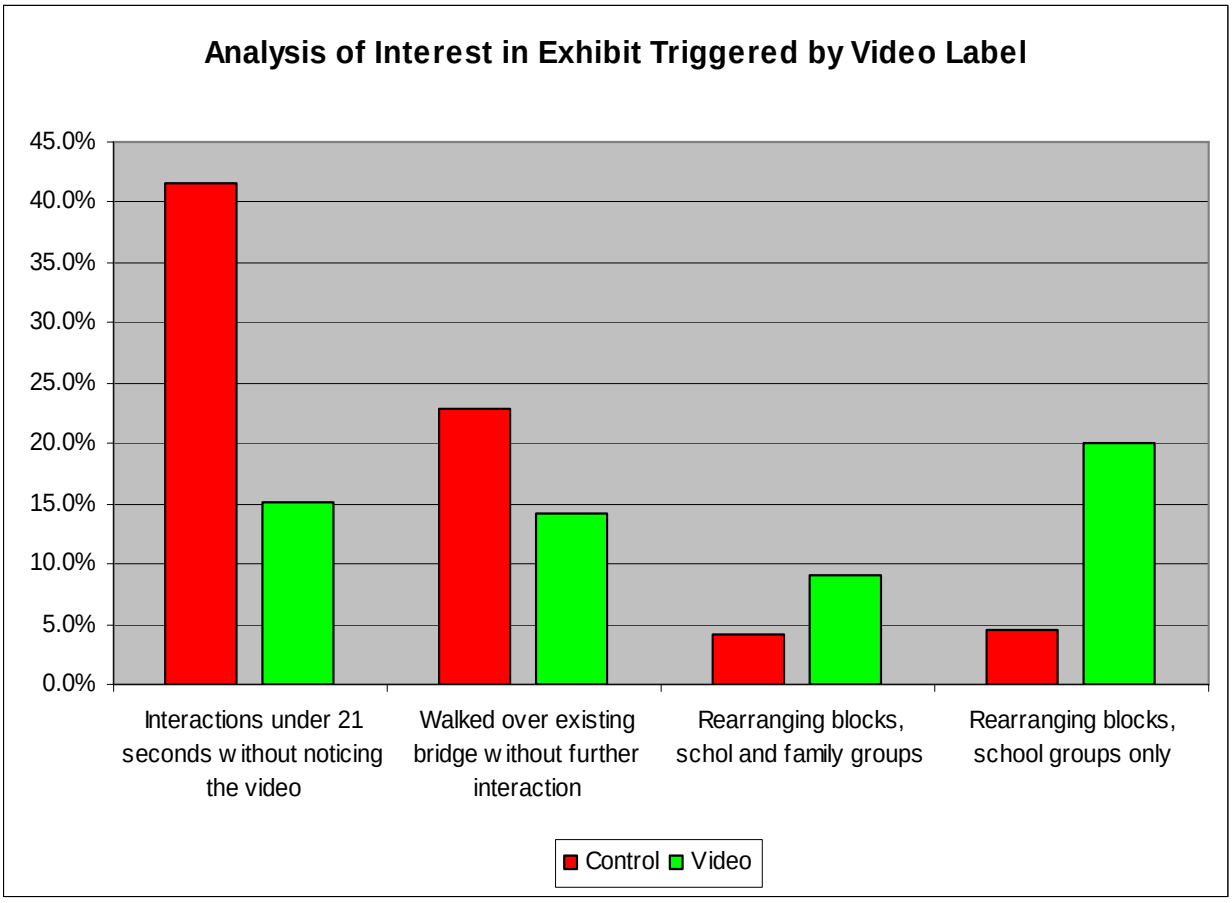


Figure 29: Analysis of Interest in Exhibit Triggered by Video Label

When the video label was installed, more visitors showed a deeper interest in the exhibit, and began to interact more completely by rearranging the blocks. In our observations we differentiated between children that were interested in constructing a bridge, and children who were only interested in playing with the blocks. This was done by marking a visitor as "started to build bridge" when they began to place blocks on the edges of the bridge. This allowed us to filter out children who were attempting to use Arch Bridge properly from the visitors who were not interested in completing a successful interaction. Our observation data shows that slightly more visitors began to interact with the exhibit (moving blocks, not doing anything constructive) when the video was installed versus when only the text label was present. (See Figure 29) There

was however a large increase observed for school children, jumping from 4% to 20%. This figure includes only visitors that were observed aimlessly playing with the blocks. The Fisher Exact Test yields a p-value below 0.05 and therefore indicates that this pattern is a result of the installed video label. The majority of children who were observed playing with the blocks were alone and interacted for less than 35 seconds with the exhibit. Furthermore the majority of these observed visitors had been paying attention to the video during much of the 35 second time span. The trend for visitors to leave after such a short time span with no successful interactions may be due to the trend that often times school children approach the Arch Bridge alone, while family groups tend to stay together and approach Arch Bridge at the same time. This usually provides an adult to help construct the bridge, which encourages successful interaction. Children that were interested in constructing the bridge but did not have any help (approached alone) usually noticed that they would fail if attempting to build the bridge alone, after watching the video point out that help would be required. This helps to point out how carefully a video label needs to be designed, because in this case the idea of encouraging social interaction had a negative impact on interactions. Most children who realized help would be required to complete the bridge did not interact with the exhibit, because the video shows that they would fail. This trend was observed only for school groups, because families tend to stay together. A variety of reasons might explain why school children were not encouraged to ask for help but rather tended to give up on the exhibit without trying it. One possible explanation is that the video encouraged the visitors to enlist the help of an adult so that they could hold the blocks to build the bridge. This however can be a problem for school children who may be too socially distanced from their teachers to ask for their help. Furthermore the school children may not be willing to ask the explainers for help because they are strangers to them, and children are often warned by parents to stay away from strangers. Our results concerning the success of the video label to encourage children ask for help indicate similar effects, which are discussed later.

One of our main goals with the video label was to promote interest in Arch Bridge and hopefully encourage visitors to build more bridges, and to test the bridges that they spend time constructing. A successful use of the exhibit should begin by taking apart an already constructed bridge if one is present, and then should include the construction of a visitor's own bridge. Then to appreciate the stability of the structure, children should test it by walking over it or standing on top of it.

Our observation data overall indicates that the video raised interest and encouraged visitors to interact with more Arch Bridge successfully overall. (See Figure 30) The key activity to engage visitors approaching Arch Bridge was for them to take apart any existing bridge, rather than have them walk over the existing bridge and leave. Only about a third (36%) of all observed children took apart an existing bridge when only the text label was present, if they found the bridge already assembled when the text label was present. This percentage increased significantly to 51% when the visual instructions were present on the exhibit. When differentiating between school and family groups, it becomes evident that the video had a far more successful impact on families than on school groups. Only four percent more school group visitors took apart the bridge when they found it assembled. On the other hand however, our observation data indicates that the school groups seem to be more encouraged to disassemble

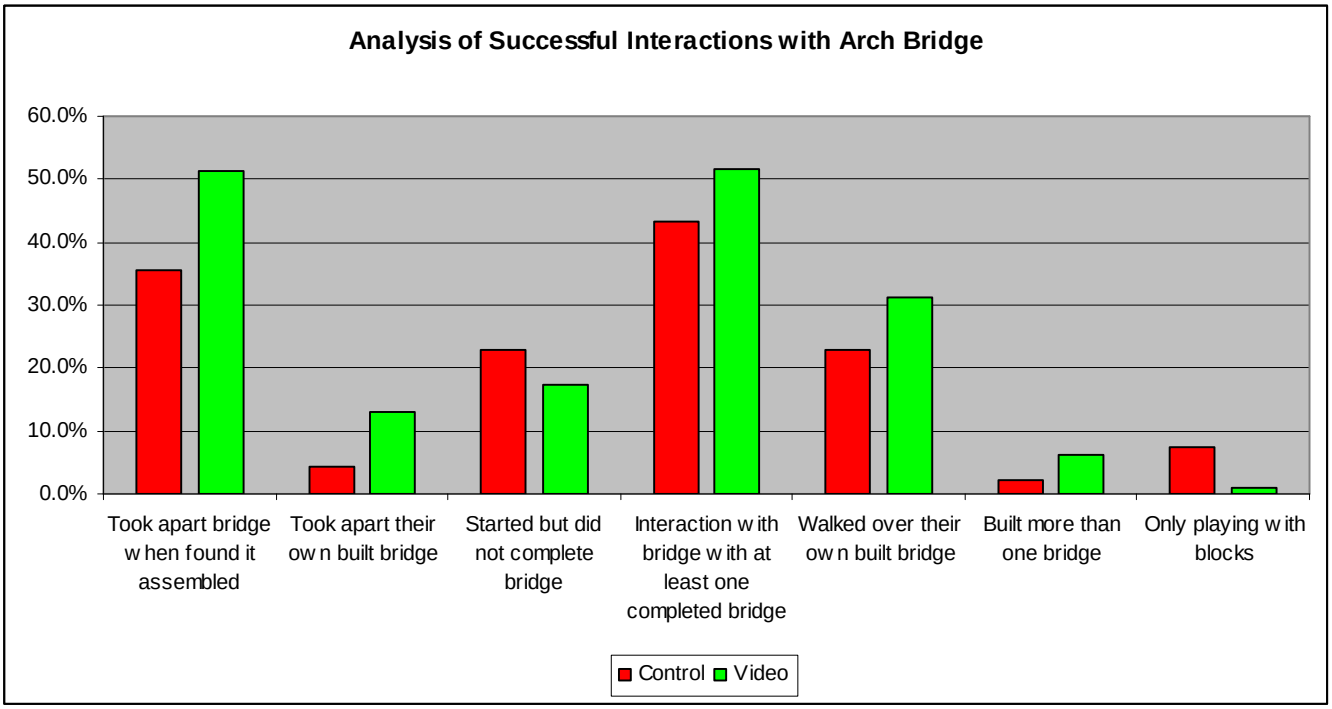


Figure 30: Analysis of Successful Interactions with Arch Bridge

their own bridges when the video was present. Where only 4% of the school children took apart a bridge that they had already built in the control group, about 11% took their own construction apart when the video label was present. This might indicate that school children misunderstood the video, even though the instruction was phrased as "First, take the bridge apart" (See APPENDIX P).

Overall increase in percentage of visitors who took apart their own bridge increased from 4% to 13%. The chi-squared test yields a p-value of 0.04 and therefore indicates the validity of our sample. Visitors usually took a bridge apart either to rebuild and improve it, or because they assumed it to be necessary after watching the video. Accordingly, the number of visitors that built more than one bridge increased from 2% to 6%. This also shows that visitors were more engaged with the exhibit and demonstrated a higher interest level in the construction when the video label was installed. The fact that the amount of people who were starting to build a bridge but did not successfully complete the structure decreased from 23% to 17% may also show that visitors were more challenged by the exhibit, and interested in finishing the construction, or that they more clearly understood what to do. Many visitors were observed consulting the video after their first failed attempt, and then went back to complete the bridge that they had started before. However, we do not have precise numbers to support this hypothesis because this behavior was accounted for as a completed bridge rather than a started and later finished bridge. A further indication that interactions with the exhibit were more successful is in the fact that the number of observations that included interacting with the bridge, and completing at least one bridge increased from 43% to 52%. Also, about a third of the visitors that watched the visual instructions at some point during their interaction with Arch Bridge completed their first attempt at constructing the arch. Moreover, fewer children played around aimlessly (e.g. kicking the blocks) with the Arch Bridge equipment (around 16 out of 200, also known as ~10%). The number of times visitors were observed playing was rather small for all samples, but was nearly zero for the samples that included the video label.

A successful interaction will ideally end with the visitor testing the bridge by walking over it, standing or sitting on it, to test the stability and strength of the structure. During our observation we were able to notice an increase of visitors that were actually evaluating their own built bridge, the percentage going from 23% when there were no visual additions to 31% when the video was added.

4.2.2.2 Effect of Video Label on Social Interaction

Our video was intended to encourage children to ask their parents, teachers or explainers for help when constructing the arch bridge. We hoped to increase social interaction and encourage young visitors to enlist the help of an adult at the Arch Bridge to help make an interaction more successful. However, our observation variables related to this goal did not indicate any major impact on visitor behavior. To analyze social interaction, it was necessary to clearly differentiate between school and family in order to be able to discuss the impacts of the video label on social interaction.

One important observation that is evident in both the school group and family group data was the lack of requests for explainer help made by visitors. It was striking to notice that none of the 197 observed visitors took the initiative to ask an explainer for help, even though they are clearly available around the Launch Pad. However, many children did realize that help would be required to complete the bridge and accordingly asked their friends or family for help, especially when the video label was installed.

4.2.2.3 Effect of Video Label on Family Group Social Interaction

Families tended to approach the exhibit as a group, where usually a child would approach the bridge or the blocks first, and start to assemble the bridge while the parent would watch until she or he notices that the child would need help at some point and then voluntarily assist their children in building the arch bridge. The video label had a positive effect on this behavior. (See Figure 31) The number of parents that helped their children out by holding up blocks or adding them to the construction increased from 28% to 37%. Accordingly, the percentage of parents that simply watched their children, or gave advice without actually interacting with the exhibit decreased. This helps to demonstrate that parents were more encouraged to help their children out as the video demonstrates. In about 26% of all interactions that were observed for family groups and included the video label, the parent watched the video long enough to be clearly visible to the observer, or referred to it by pointing at it during the interaction. The qualitative analysis further discusses the fact that many families with children outside the age range were observed interacting with the exhibit, typically displaying the same behavior.

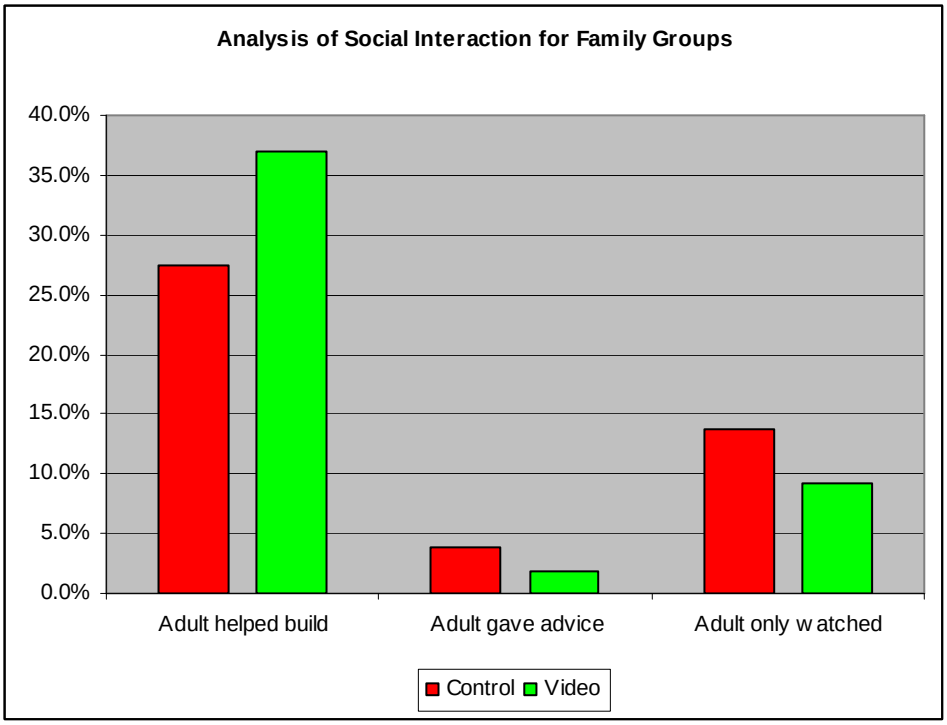


Figure 31: Analysis of Social Interaction for family groups

4.2.2.4 Effect of Video Label on School Group Social Interaction

The observation data for school groups indicated that the amount of adults that helped the child visitors decreased significantly from 13% to 4%. However, these percentages reflect the actions of six and two adults respectively, and cannot accurately assume this to be a pattern found if further observations were to be conducted. It is nevertheless interesting to analyze possible reasons for this behavior. In general, the already mentioned adult to child ratio seems to play an important role because it provides the key difference between family and school groups, and helps to explain this very different sample. There are fewer adults around when children visit the museum in a school group, because the museum only requires 1 adult for every 8 school children. Also school children more often do not approach the Arch Bridge as a group (as mentioned previously families usually stay together in the Launch Pad). It therefore seems reasonable to argue that children tend to ask their friends that are at or around the Arch Bridge for help instead of their teachers. This was a frequently observed behavior and will be discussed in section 4.1.3 in further detail. Similarly, the average group size for school groups increased from 2.4 visitors per interaction to 3.0 visitors per interaction for interactions that lasted longer than twenty seconds. However there was no remarkably observable change in the average group size for families. This helps to show that children were encouraged to approach the exhibit in larger groups, or ask friends for help while building Arch Bridge.

As mentioned previously, the social distance between students and teachers could help to explain the child visitor's decision to ask for help. Our observation data offers a variable that helps support this. While parents of family groups were encouraged to help their children out instead of simply giving advice, the percentage of adults that only gave advice went up for the observed school groups. However, these percentages did not change by a large enough margin to say conclusively if any positive change occurred.

Another behavior that we tested to see if the video could correct was the common

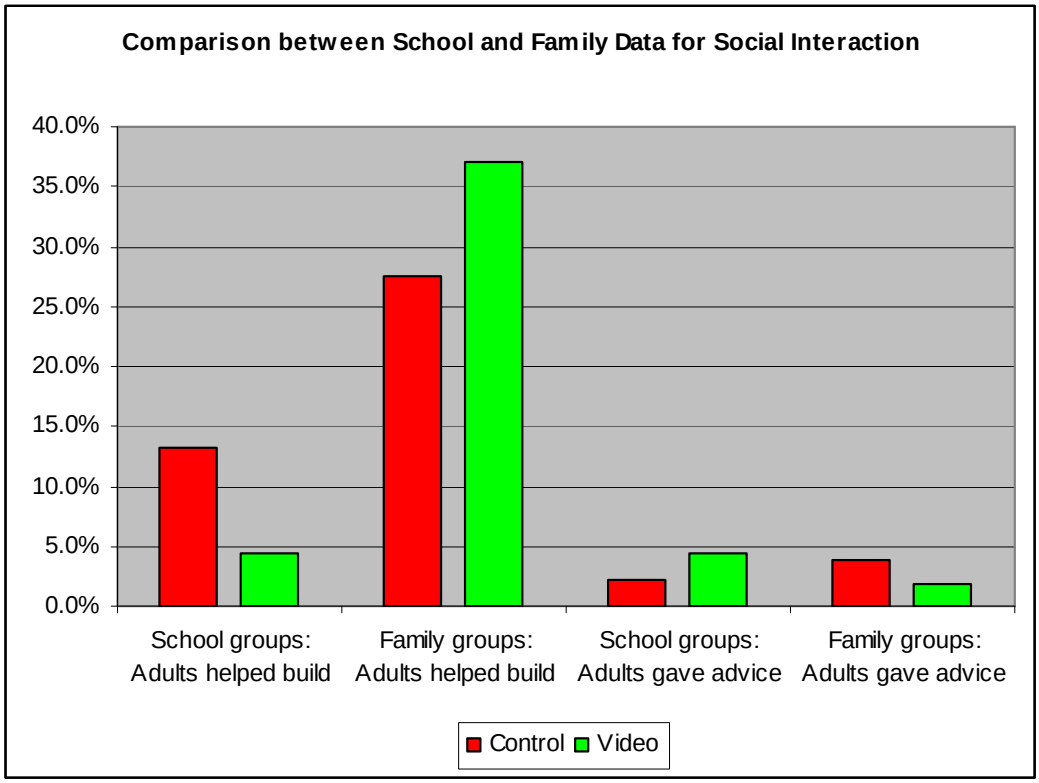


Figure 32: Comparison between School and Family Data for Social Interaction

misunderstanding that visitors had concerning where to build the bridge (See Figure 33). We noticed during our pre-testing that often times children were misusing the guide located behind where the bridge was intended to be built. Often times visitors would see the guide as a place to build the bridge rather than as a support for a completed bridge[48]. We intended to use the video as an example of correct use, and hoped that the visitors would realize that the guide was not necessary for either the construction of the bridge, or walking across the bridge. However, we

[48] For more information about this problem please refer to section 4.1.3

Figure 33: Arch Bridge, Guide

did not include explicit instructions or explanations to point this out, but rather hoped that by seeing the example done correctly children could follow it and apply it to what they were building. Understandably, the impact of the video label on this behavior was marginal. The percentage of children that started building by placing the blocks on top of the guide decreased from 16% to 13% showing that a more detailed and focused instruction is needed to remedy this problem, and problems like it. During our observations only very few children (2%) walked over the guide while building or after completing the bridge. Interestingly, most of the children that stood on the guide instead of the bridge tried to push the bridge down and therefore needed the guide in order to be able to stand. As a result, we cannot draw any direct conclusions about the impact of our video label on this interaction behavior.

4.2.2.4 Grouped Time Interaction for Arch Bridge

Earlier, we were able to use the interaction time analysis for Turntable to help demonstrate a change in the visitors' behavior. For Arch Bridge this was not possible because the results are too similar and the small differences cannot be exactly attributed to the presence of the video label. The data for the video is slightly skewed to the right, indicating that children were spending more time on average at the exhibit when the video label was added. Accordingly, the average interaction length increased from about 57 seconds to 75. However an analysis of the distribution of percentages over intervals (See Figure 34) does not show

significant changes other than the fact that there are more outliers to the right for the video label data.

We originally planned to measure the success of an interaction also by grading the quality of every completed arch bridge. To measure the quality of a bridge we evaluated each bridge built on a scale of 1 to 5, with 5 being a perfect example of how the bridge is supposed to appear. This however proved to be infeasible mostly because the video label lacks explicit instruction or guidelines on how to build the bridge but rather shows only an example that the children are supposed to imitate. The observed change was marginal (bridge quality average changed from 3.8 for the control samples to 4.1 for video label samples) and we were not able to use it to support or test our hypothesis with any implied accuracy.

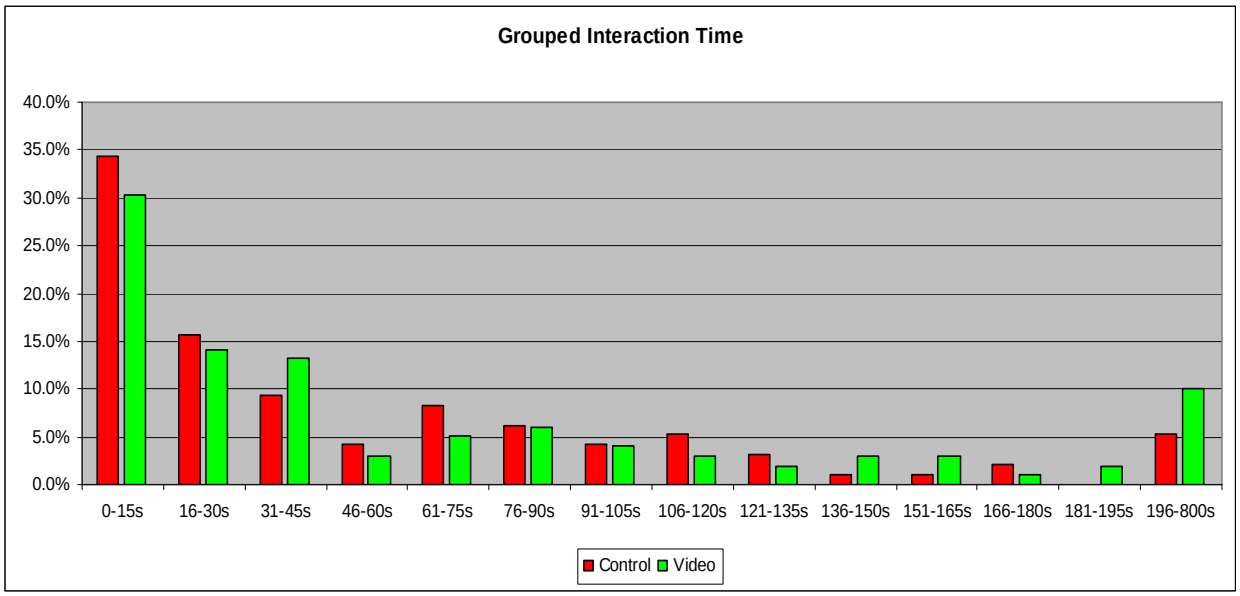


Figure 34: Arch Bridge, Grouped Interaction Time

4.1.3 Qualitative Analysis for Arch Bridge

Unlike Turntable, the qualitative analysis for Arch Bridge was only based on comments made about behaviors or events that the observer kept track of by noting down in the comment section of the observation form. Comments were usually made where they would clarify a visitor's behavior, or to record a behavior that became apparent throughout our observation that had not been identified during our pre-testing.

One very interesting observation we discovered was that many children tended to imitate the behavior of the explainer and child in our video label. When designing the label we did not

expect children to stand on top of the built bridge and cheer in the same way that was demonstrated in the video, but rather had intended to use this clip to add humor to our label. Nevertheless, a small group of children also copied the explainer's actions very closely by flexing their muscles while standing on top of the bridge, in a manner than can be clearly tied to what the had seen on the video. This behavior helps to clearly indicate that children were watching the video, and were not cheering simply because they had successfully built the bridge. Additionally, there was no cheering or flexing observed when the video label was not present at the exhibit.

Also, during our observation we noticed that a majority of parents tend to reproduce the behavior of the explainer, especially if they are building the bridge with children that are eight years old and younger. They usually started building the bridge from the left side and have their children bring the blocks one by one while they hold up the construction, as was demonstrated in the video. They also tended to finish the construction by adding one of the outside stones last, like demonstrated in the video label, instead of adding the top stone, or keystone last.

We noticed that the text label for Arch Bridge was leading many adults to assume that the narrow guide in the back of the exhibit was the support that is mentioned in the instructions. However, we removed the two supports that are mentioned on the text label according to our informal interviews with the visitor research department. This misunderstanding was influencing parents to instruct their children incorrectly, instructing them to build on the guide. Nonetheless the text label was visible during all our observation phases, and therefore should have had the same impact on all four samples. It was interesting to notice that often times while parents started building the bridge on top of the guide, their children watched the video and then corrected their parents, and instructed them to build the bridge without the help of the guide.

A significant number of school children were observed calling for help before they had started to build the bridge or while trying to construct it. This behavior was mentioned in our quantitative analysis previously, but we cannot provide descriptive statistics about it because we started observing this behavior only after we had added the video label, and therefore did not include this variable on our original observation form. However, a noteworthy number of visitors called for help from their friends, rather than getting an adult like the video demonstrated. We did not observe many families where the parents and children were separated. Therefore it is difficult to identify whether children were asking parents, who were standing right

next to them, for help or whether the parents were offering their help without the child taking the initiative.

Throughout all four data samples, it was observed that it was difficult for visitors to realize how the bridge is correctly built when they approach the exhibit to find the reds blocks already incorrectly placed on top of the guide. (See Figure 35) Even if only a single stone was left on top of the guide, it was common to observe the "domino effect" that it had on visitor behavior, because the following groups of visitors would try to complete the bridge on top of the guide, believing that the visitors before them had the right idea.

Figure 35: Arch Bridge, Blocks on Guide

5.0 CONCLUSIONS AND DISCUSSIONS

This project was aimed at studying the effects of adding visual labels to exhibits in the London Science Museum's Launch Pad gallery. Specifically, we investigated two particular exhibits, the Turntable and the Arch Bridge, through a combination of observations and visitor interviews. The first exhibit, the Turntable, was tested using both a slide show label, and a video label, and data was gathered by conducting simultaneous observations and interviews with visitors ages 8 – 14. The second exhibit, the Arch Bridge, was tested using only a video label, and only through the use of visitor observations. When investigating each exhibit, we were specifically interested in measuring the effect our labels had on successful use, average interaction time, connection to real life, social interaction, and behavioral changes.

The base line finding was that adding a visual label to an interactive exhibit fundamentally alters how visitors will use that exhibit, however not always in a predictable manner. Here we will outline some of our most important findings, as well as discuss why we believe they occurred and what potential they have for future exploration into visual labeling. We also detail some suggestions for further work, to help expand knowledge of exactly what kind of effects can be expected through the use of visual labels.

5.1 Conclusions

The first, most obvious and most critical conclusion that we can draw from our data is that visitor behavior can be changed in a fundamental way through the use of visual labels. Evidence to support this is shown by the way behavior was clearly changed at both the Turntable and the Arch Bridge throughout the observation period. Ii is easiest to highlight the successes of the video label because it was displayed on the largest screen, and at an angle that made it easiest to view. With both exhibits we studied the video label resulted in more successful interactions as well as drew visitor attention to the label, to a degree that was not observed when only the text label was present. While there are several hundred possible reasons why visitors may have paid more attention to the video label then they did to the text label, only several of the most promising ones will be explained here. The first possible explanation is that the video label provided a very strong contrast to the rest of the Launch Pad gallery. The Launch Pad is an entirely interactive gallery, and at the time this paper was written does not contain any visual

labels like the ones we tested. Instead the only labels present in the gallery are what the staff refers to as "surfboards" which are text labels that are shaped like an elongated oval, or a surfboard. Because no visual labels exist in the Launch Pad we believe that visitors were attracted to the fact that the visual labels simply looked different from the rest of the gallery. Also the prototype housing that had been designed for the visual instructions was made from a table that had white cardboard draped over the sides and taped on with duct tape. To increase the prototypes visual appeal we decided to drape a black piece of cloth over it and then tape that to the sides. The end result however did not look very professional, and may have gotten some attention only because of that particular detail.

Another reason we believe that the video label attracted attention in the Launch Pad was simply because the video label closely resembled a TV set, and children are very used to watching TV and imitating behavior they observe. Also in the particular case of the Turntable, visitors may have watched the video because they were standing in line without anything else to keep them occupied.

One important difference that needs to be considered when evaluating the overall success of the video label on Turntable and Arch Bridge is the differences between process focused and outcome focused exhibits. Turntable is a process focused exhibit, meaning that a successful interaction with Turntable will not yield any sort of tangible outcome. Rather a successful interaction depends on how the visitors interact with Turntable when they are using it. A successful interaction with Turntable requires a visitor to start themselves off leaning back and then to lean in and out and notice how leaning affects their speed. This procedure of leaning defines Turntable as a process focused exhibit.

Arch Bridge, however, is an outcome focused exhibit far more than it is process focused. The idea behind Arch Bridge is for a visitor or group of visitors to construct a bridge out of the provided blocks. Although the process of walking over the bridge is important it is still the focus of the exhibit to first get the bridge constructed. The bridge that the visitors built at the end provides a tangible concrete outcome. Therefore Arch Bridge is an outcome focused exhibit.

The difference between process and outcome focused exhibits is something that should be considered before any type of visual label is implemented. One example can be illustrated by the testing of the slide show label on the Turntable exhibit. One reason why we believe the slide show was not as effective on the Turntable as the video was is because the slide show is trying to

illustrate a process using a series of 5 static pictures. It can be very difficult for a child visitor to interpret a series of pictures detailing how to do something, and then actually repeat that process after having only a few seconds to process the information. The video however clearly shows the entire process of leaning in and out on the Turntable in a very accessible format. The process of imitating what a visitor sees demonstrated to them through a video may have in this case been an easier connection to make than the connection between the instructional slides and correctly using the exhibit.

From the evidence we have gathered we can also draw conclusions about what kind of behavioral changes can be expected and encouraged through the use of visual labels. One of the most predominant examples of behavior being affected by visual labels was the example of children who imitated the cheering and muscle flexing behavior of the explainer from the video. During the taping of the Arch Bridge video the explainer we filmed decided to celebrate successfully completing the bridge by flexing his muscles and cheering while standing on the bridge. To encourage children to test the bridge they build we decided to include this footage in the prototype version of the video. Interestingly enough, when we began observing the Arch Bridge when the video prototype was in place, we noticed several children imitating this behavior to a degree that almost entirely rules out coincidence. This imitating of behaviors presented in the video label did not only occur with the Arch Bridge however. When we interviewed children when the prototype video was installed several of them quoted lines from the video to help illustrate their point when answering a question. Behavior such as this strongly suggests that children are willing to watch and remember what they see in video instructions if presented in an accessible format.

On the other hand, however, behavior such as this can help to illustrate how important it is to carefully consider what footage goes into a video label. When we added the footage of the explainer cheering we did not expect that visitors would imitate it, and were rather surprised when they did. This implies, however, that visitors may take details out of video labels that the creator of the label did not intend, and possibly did not desire. To avoid this is would appear that careful testing should be done on labels, to avoid any miscommunications between the visual label and the visitors.

5.2 Suggestions for Improvement

Throughout the course of this project several problems and small setbacks were identified that could be eliminated if care is taken. Here we have outlined as many of these as possible, to help point out possible pitfalls for anyone wishing to further investigate visual labels in a similar setting.

One problem that we experienced that could be avoided with enough planning was the placement of the slide show and the video. Because the placement of both prototypes was out of our control during the testing, mostly because of where electricity was and was not available, there was little we could have changed to increase the success of the prototypes by adjusting where they were placed. However through the research we conducted prior to beginning testing we discovered that the placement of labels is extremely important and can have a large effect on the results. One suggestion we had was to maximize the placement of the slide show by moving higher off the ground and, therefore, making it harder to block. Often times we observed visitors who were accidentally standing in front of the slide show label while waiting for their children to finish using the Turntable. This can be a big problem because the screen that was used to display the slide show was only 7 inches diagonal and can be totally blocked to the point that other visitors do not even realize that it is present. To help with this we recommend that labels are placed somewhere that they are difficult to obscure, yet still easily visible to the visitors in line for the exhibit.

Another problem that the slide show faced was how low it was to the ground, and the angle it was directed at. The table that we used to display the slide show prototype was only 2 ½ feet off of the ground, and the slide show was mounted to so was flat on the table, meaning that it was projecting its image perpendicular to the ground. Although this setup may prove ideal for young children it can be extremely difficult for the adults that accompany children to read the instructions and provide help. The distance that the label was from the ground may also have contributed to the amount of adult visitors who blocked it, because if adults did not notice the label, then they would not realize that they were standing in the way. To this end we would suggest that if a slide show was to be used to display instructions, and the screen size was comparable, then the label should be placed higher so that it can be used easily by all audiences, including the target audience.

One other suggestion that we had was to increase the size of the screen that the slide show is displayed on. Rather than suggest a specific size that should be used, we will only recommend that the environment that the instructions are going to be used in be carefully considered, so that the slide show can be large enough to be seen but not so large as it overwhelms nearby exhibits.

Furthermore during our testing one common behavior we noticed was that often children thought that the slide show label was an interactive touch screen rather than a series of static images that are looped. To prevent this we would recommend that if a similar slide show setup was to be used, that the picture frame itself be encased in plastic so that visitors cannot actually touch the screen. Doing this would hopefully serve two purposes. The first would be that visitors would quickly recognize that the slide show is not an interactive touch screen and is in fact a series of instructions. Hopefully then the visitor would be more inclined to pay attention to the instructions rather than tap the screen for even longer. The second purpose behind doing this is to prevent the picture frame from being damaged by countless visitors poking at the Liquid Crystal Display. Typically LCDs are fragile and can be easily cracked. Putting the picture frame behind plastic would prevent this from happening and also take a potential safety hazard off gallery.

One suggestion we discussed was to move the location of the label on Turntable so that it can be seen both from the line, and from the exhibit itself. We believe that part of the reason that the video label did not have as dramatic an effect on school groups as it did on family groups was because of the simple tendency for school groups to gather around the outside of the Turntable rather than form a line. Because the location of the video label was set so that it could really only be viewed from the line, most likely a large number of the school group visitors in our data set did not even see the label until they left the Turntable. Also if the label to the Turntable was placed so that the visitors using the exhibit could see it, they would have the opportunity to refer to it without losing their place in line. This would be helpful if a visitor was confused on a particular aspect of how to use the Turntable, for example how to start spinning. The way that it was set up during testing required visitors who saw the instructions to learn how to use the exhibit before stepping onto it, and then hopefully remember it. With Arch Bridge however this was not the case, the label was clearly viewable from the exhibit, and it was not

uncommon to see visitors looking back at the label to make sure they were building the bridge correctly.

5.3 Recommendations for Further Work

To continue work towards understanding how successful visual labels could be, it would be important to look further into how well a similar slide show set up could improve a different exhibit than the Turntable. Despite the lack of positive results that the slide show provided with Turntable, we believe that it would still be worthwhile to investigate how well the slide show would perform on a different type of exhibit. As mentioned before, Turntable is a classic example of a process focused exhibit, where the important aspects of the interaction lie in exactly how a visitor goes about the process of leaning in and out. However, the slide show may not have been the best choice to illustrate a process based exhibit because of the complexity involved in relaying exactly how a visitor is supposed to behave in such a short period of time. The slide show may prove to be more effective in conveying instructions about an exhibit that is more focused on outcome, like the Arch Bridge. With Arch Bridge the most important variable necessary towards a successful interaction is the completion of the bridge by the visitors. Building the bridge is a stepwise process that may be easier to illustrate using a series of static images than text or even a video. Studying the effects that a slide show would have on other outcome-based exhibits would also help to prove if a slide show label would provide visitors with enough information to complete successful interactions.

Also, further studies could include taking the concept of a visual label on step further, using 3D animations rather than video footage or static visual instructions. The possible advantages of 3D animations are that they are particularly eye catching and appealing, and can be designed to show exactly what is desired while at the same time eliminating from view everything that had no part in the instructions. Essentially this eliminates one of the potential problems that video labels can experience, which is that visitors can be focusing on insignificant details of the exhibit, rather than focusing on the important part of the instructions. With 3D animations, however, only the essential parts of the instructions are included, and nothing else is present to distract. Furthermore 3D animations can eliminate the problems associated with taping how something is supposed to work because no thought needs to be put into considerations like camera angle and speed. Also 3D animations would allow a specific stage of

the instructions to be highlighted as being really important to the interaction while using a minimum amount of text and time.

Another important variable to study would be the average amount of time that visitors spend using visual labels. This would prove to be very important to design labels that can get all the information a visitor needs to successfully interact with an exhibit, in a reasonable amount of time. This would also allow comparisons to be drawn between how much time visitors spend using text labels verses how much time visitors spend on visual labels, and if an observed increase occurs. The results of a study like this would be very important when considering how to successfully design labels short enough that visitors will be willing to spend the appropriate amount of time at.

Another variable that would be interesting to test would be how important is it to child visitors who is shown in the video label. For example, would an explainer be a better choice then using children recruited off gallery, or even child actors? Also it would be helpful to test if using a male or female child would encourage or discourage a different demographic to use the exhibit. For example would a 14 year old girl being featured on a video label discourage boys from interacting with that particular exhibit? This type of data would prove important if the museum would like to carry out producing video labels for its exhibits because they would have to take care not to exclude any gender or age groups.

ANNOTATED BIBLIOGRAPHY

PSYCHOLOGY

Hegarty, M., & Sims, V.K.. Individual differences in mental animation during mechanical reasoning. Memory & Cognition, 22, (1994): 411-430. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=7934947&dopt=Abstract

> This abstract contained these 4 points: "(1) sentence comprehension, (2) diagram comprehension, (3) text-diagram integration, and (4) mental animation" which redirected our research to the article "Mechanical reasoning by mental simulation" by Mary Hegarty.

Mary Hegarty. "Mechanical reasoning by mental simulation." Trends in Cognitive Sciences, 8, no.6, (2004): 280-285. http://www.psych.ucsb.edu/~hegarty/Hegarty%20TICS%20final.pdf

> This article identifies two fundamental approaches that humans solve mechanical problems with – mental (or spatial, which in this context is the same thing) simulation, or by applying explicit knowledge. It links to a number of experiments all of which support that if a conscious mental image of the complex mechanical system is in the person's head, they will qualitatively predict the system's mechanics (at least to some degree) bypassing the verbal component. That is, "There is a strong dissociation between spatial and verbal ability." (p. 281).

Bradley D. Ausman, Huifen Lin, Khusro Kidwai, Mine Munyofu, William J. Swain and Francis Dwyer. "Effects of Varied Animation Strategies in Facilitating Animated Instruction." Association for Educational Communications and Technology, (2004).

> This article indicates that while animation and audio are often viewed as "virtual panacea" for all kinds of messages, it is not always effective. In fact, the authors state that if little concern is taken for systematic placement, the animation can do more harm than good! Then they discuss what makes the animation effective.

Francis Dwyer. "Strategies for improving visual learning: a handbook for the effective selection, design, and use of visualized materials." State College: Learning Services (1974)

This book, while old, is a handbook in creating effective visuals, and is a classic in related literature, cited by articles as late as 2001. At the end of every chapter there is a concise summary of main points, one of which is "For visualization to have maximum effectiveness in complementing oral/print instruction, it should be specifically designed to improve learning and should be presented simultaneously with the information it has been designed to illustrate and clarify."

Stephen Bitgood. The Role of Attention in Designing Effective Interpretive labels, Journal of Interpretation Research, Vol. 5. No. 2. Pp. 31-45.
http://www.jsu.edu/depart/psychology/People/bitgood/5.1-role_of_attention.pdf

Discusses the role of attention and accordingly guidelines on how to catch a user's attention with attractive/successful labels. Talks about background and appearance as well as about content, which is what makes this paper valuable.

INSTRUCTIONAL ANIMATIONS

Tversky, B., Morrison, J. B., & Bétrancourt M.. "Animation: Can it facilitate?" International Journal of Human-Computer Studies, 57, (2002): 247-262.
http://www.sims.berkeley.edu:8000/courses/is247/f05/readings/Tversky_AnimationFacilitate_IJHCS02.pdf

This article speaks of the benefits of graphics for transferring information and teaching principles of complex informational and mechanical systems. It also contains a section on why an instructional animation can fail. It also contains an extensive list of citations that may be useful for further research

Educational animation on Wikipedia, the free encyclopedia, http://en.wikipedia.org/wiki/Educational_animation (2006).

While this Wikipedia article is not a legitimate source of factual data, it provides a very good list of citations; unfortunately, WPI does not subscribe to most of the journals mentioned in those citations. The authors mentioned however are very influential in the field – namely Mary Hegarty, Psychology professor in U.Cali.

INTERACTIVE EXHIBITS OR MORE GENERAL SOURCES

Stevens, R. and Hall, R (1997). *Seeing Tornado: How Video Traces Mediate Visitor Understandings of (Natural?) Phenomena in a Science Museum*. Science Education, 81(6), 735-748.

We were referred to this paper by Dr. Alexandra Burch. She mentioned that the idea of our project was based on this paper, indicating the significant importance itself and its references have. The project itself was not entirely what the London Science Museum is planning to do but is giving a good background knowledge on where current research in this field of education is.

Introduction to Experience-Based Exhibits. http://www.scienceservs.com/id14.html

This site outlines what hands-on exhibits are and what they are used for and some of the ways to make them successful. It has a link to articles by Ted Ansbacher on the same topic.

Ansbacher, Ted. "What did you see and do?: A Brief Introduction to Experience-based Exhibits" *Informal Learning Review*, Jan/Feb 2000
http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/briefintro.pdf

It is more important that museum visitors remember what they saw and did at the museum that to gain a piece of specific knowledge. Experience-based versus information-based. Labels should be used to facilitate the visitors' experiences in interacting with the exhibits and help connect them to their lives.

Ansbacher, Ted. "Interview with John Dewey on Science Education" *The Physics Teacher* Vol. 38 April 2000.
http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/deweyonscied.pdf

An interview by Ted Ansbacher with John Dewey. Some questions about hands-on learning.

Ansbacher, Ted. "Misunderstandings of Meaning Making" *Exhibitionist*, Vol. 21, No. 1, Spring 2002.
http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/mythsofmm.pdf

"meaning making" is what visitors do at hands-on exhibits with the goal of engaging the visitors.

Ansbacher, Ted. "If Technology is the Answer, What was the Question? Technology and Experience-Based Learning" *Hand to Hand* Vol. 11 No. 3 Fall 1997.
http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/iftechnology.pdf

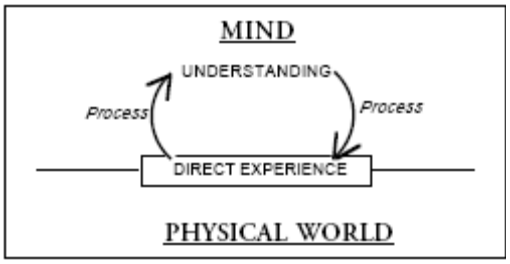


Figure 1: A model for experience-based learning

Museums and informal education
http://www.infed.org/archives/e-texts/screven-museums.htm

Online article on designing interactive exhibits successfully: "Chandler Screven examines the possibilities for informal education within museums … [and he] provides some important guidelines".

Museum Learning Collaborative
http://museumlearning.com/default.html

The website contains an searchable annotated bibliography about learning in museums in general and is a fairly extensive source for this topic.

The Journal of the learning sciences

https://www.erlbaum.com/shop/tek9.asp?pg=products&specific=1050-8406

A more general source on our topic, a journal that deals with education in a broad-spectrum

Sickle Cell Counselor: A Prototype Goal-Based Scenario for Instruction in a Museum Environment, Benjamin Bell, Ray Bareiss, Richard Beckwith
http://www.leaonline.com/doi/abs/10.1207/s15327809jls0304_3

The Museum of Science and Industry in Chicago asked The Institute for the Learning Sciences to design a computer-based, interactive video exhibit

The Science Center Movement: Contexts, practice, next challenges by John G. Beetlestone
http://pus.sagepub.com/cgi/content/abstract/7/1/5

A general source on where interactive exhibits are (1998)

Heidegger in the Hands-on Science and Technology Center: Philosophical Reflections on Learning in Informal Settings, Richard Walton
http://scholar.lib.vt.edu/ejournals/JTE/v12n1/walton.html

Discusses interactive exhibits and their usage / success for educational purposes.

Issues in Museum Interpretation
http://museumlearning.com/Lauracourse.html

Summary of a course about implementing exhibits that features a long list of introductory to intermediate resources

Maribeth Back, Rich Gold, Anne Balsamo, Mark Chow, Matt Gorbet, Steve Harrison, Dale MacDonald, Scott Minneman, "Designing Innovative Reading Experiences for a Museum Exhibition," *Computer*, vol. 34, no. 1, pp. 80-87, Jan., 2001.

Provides the following fact: "In the museum world, prevailing opinion holds that visitors do not read and that a single exhibit can reasonably expect to receive only about 30 seconds of attention."

METHODS OF INSTRUCTING FOR INTERACTIVE EXHIBITS

Ansbacher, Ted. "Experience, Inquiry, and Making Meaning" *Exhibitionist*, Vol. 18, No. 2, Fall, 1999, pp. 22-26

http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/expinquirymm.pdf

Labels in experience-based exhibits should instruct visitor's how to use an exhibit, identify parts of the exhibit, point out things to notice, pose questions, and connect exhibit to visitors' lives (versus labels that strengthen the message of an exhibit in a information-based exhibits).

Ansbacher, Ted. "John Dewey's Experience and Education: Lessons for Museums" *CURATOR, The Museum Journal*, vol. 41, no.1 March 1998

http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/deweyseande.pdf

Also talks about importance of experience-based exhibits but then goes into problems of implementing such exhibits such as social control, moving people away from their initial impulses to think further into the problem, and connecting experiences. Includes tables showing logic of how labels can work with this type of exhibit. Compares to education.

Ansbacher, Ted. "On Making Exhibits Engaging and Interesting" Curator, Vol. 45 No. 3 July 2002.

http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/engagingexhibits.pdf

Experience versus content. Should we be more concerned about the experience of the visitors or the content of the exhibits and the knowledge the visitors gain. Some good information about writing good labels.

Ansbacher, Ted. "The Rose Center for Earth and Space at the American Museum of Natural History: An Experience-Based Critique" *Exhibitionist* Vol. 21 No. 2 Fall 2002

http://www.scienceservs.com/sitebuildercontent/sitebuilderfiles/amnhcritique.pdf

"Exhibits fail as experience-based exhibits if the labels tell visitors what meanings they are supposed to make rather than facilitate their own meaning making." Invite visitors to join instead of lecturing to them.

Kelly, Lynda. "Writing text and labels: a review of the literature." *Australian Museum Audience Research Centre*, May 2000.
http://www.amonline.net.au/amarc/pdf/research/text.pdf

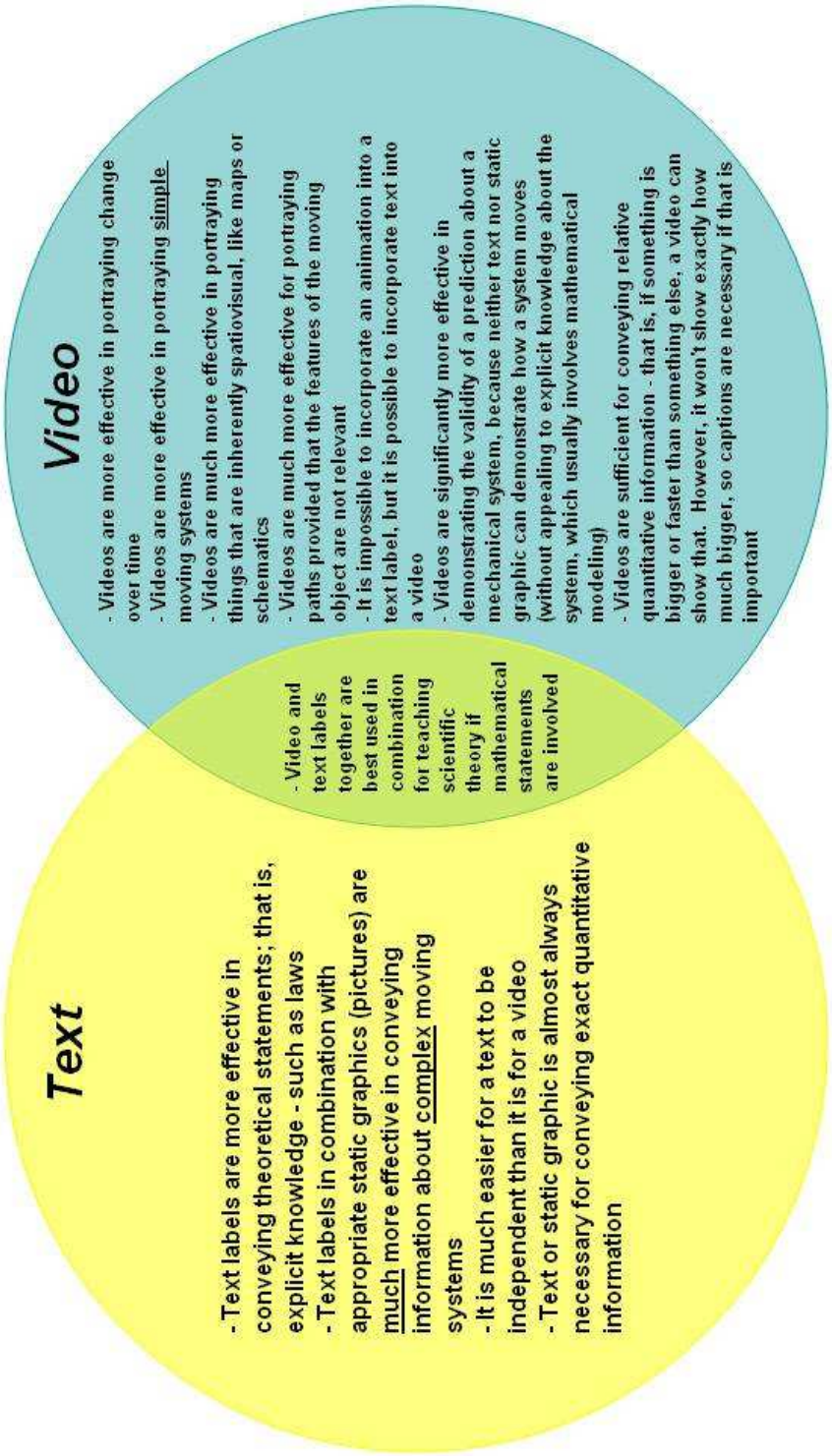
Provided this fact: "people only usually spend a few seconds reading a label so it must convey essential information in that time."

SURVEYING USER INTERACTION

Chantal Barriault, The Science Center Learning Experience: A Visitor-Based Framework
http://www.informallearning.com/archive/1999-0304-c.htm

This study investigated the behavior of visitors as they interacted with exhibits to determine if there were consistent patterns of behaviors that occur which indicate that learning is taking place.

APPENDIX A: COMPARISON OF TEXT AND VIDEO LABELS



APPENDIX B: EXPLAINER SURVEY FOR TURNTABLE

The purpose of this survey is to evaluate the effectiveness of the current instruction set for the Turntable exhibit. We want to use this data to make possible video additions as successful and helpful as possible.
Please circle the number representing your answer for questions 1 to 6.
Thank you for taking the time to give us your input, we value your help.

1. How popular is the exhibit?

Very popular	**5**	**4**	**3**	**2**	**1**	Not popular

2. How successful is the current instruction set in instructing the correct use?

Very successful	**5**	**4**	**3**	**2**	**1**	Not successful

3. How often do visitors notice the instruction set?

Always	**5**	**4**	**3**	**2**	**1**	Never

4. How often do visitors read the instructions set?

Always	**5**	**4**	**3**	**2**	**1**	Never

5. How many visitors apply what they read and use the exhibit successfully?

Always	**5**	**4**	**3**	**2**	**1**	Never

6. How successful is the exhibit in conveying the scientific subject?

Very successful	**5**	**4**	**3**	**2**	**1**	Not successful

7. Please explain why you think that the current instruction set is or is not sufficient to use the exhibit correctly?

8. Why do you think the current instruction set is or is not successful?

9. What would improve the current instruction set?

APPENDIX C: EXPLAINER SURVEY FOR ARCH BRIDGE

The purpose of this survey is to evaluate the effectiveness of the current instruction set for the Arch Bridge exhibit. We want to use this data to make possible video additions as successful and helpful as possible.
Please circle the number representing your answer for questions 1 to 6.
Thank you for taking the time to give us your input, we value your help.

1. How popular is the exhibit?

Very popular	**5**	**4**	**3**	**2**	**1**	Not popular

2. How successful is the current instruction set in instructing the correct use?

Very successful	**5**	**4**	**3**	**2**	**1**	Not successful

3. How often do visitors notice the instruction set?

Always	**5**	**4**	**3**	**2**	**1**	Never

4. How often do visitors read the instructions set?

Always	**5**	**4**	**3**	**2**	**1**	Never

5. How many visitors apply what they read and use the exhibit successfully?

Always	**5**	**4**	**3**	**2**	**1**	Never

6. How successful is the exhibit in conveying the scientific subject?

Very successful	**5**	**4**	**3**	**2**	**1**	Not successful

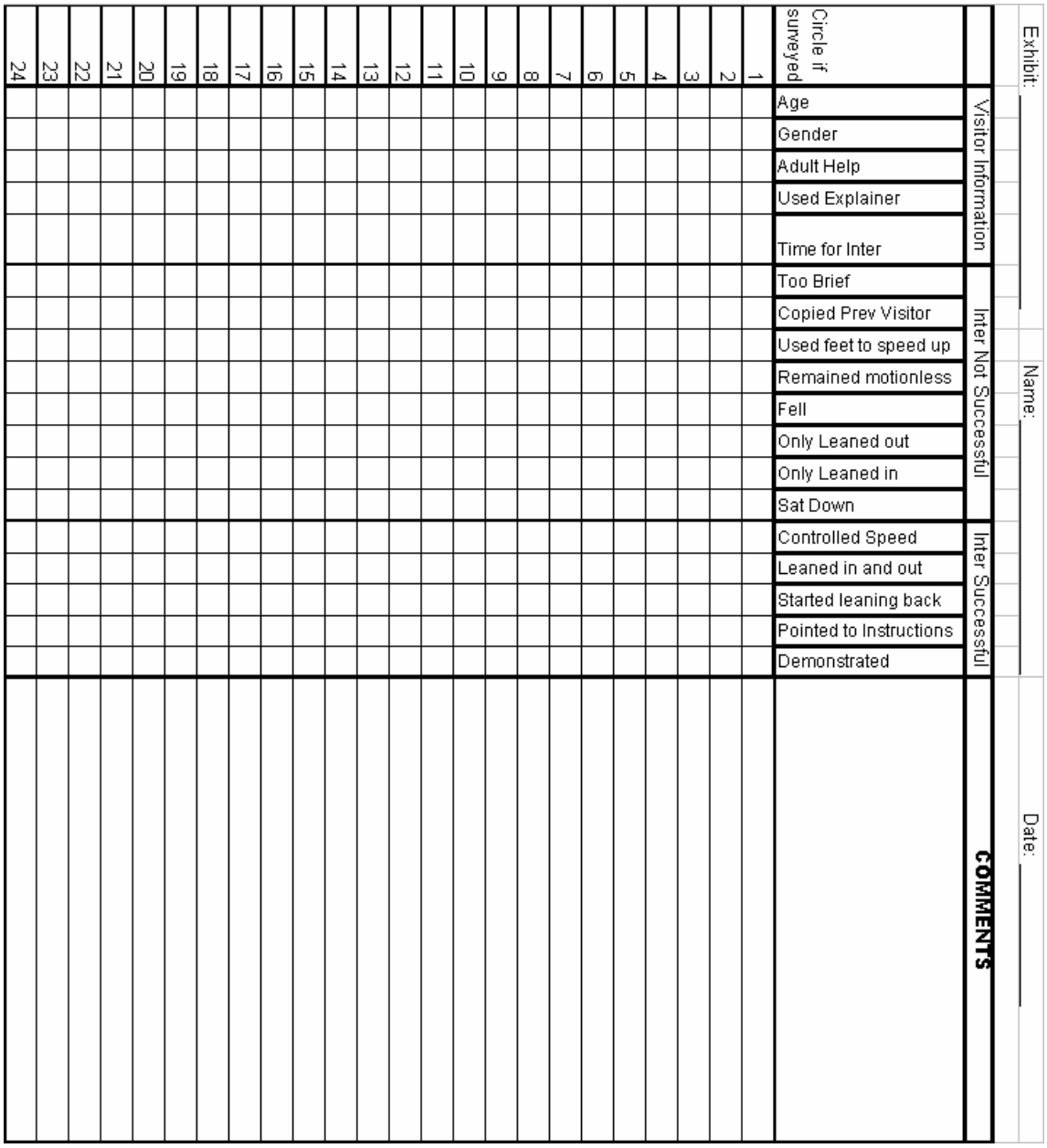
7. Please explain why you think that the current instruction set is or is not sufficient to use the exhibit correctly?

8. Why do you think the current instruction set is or is not successful?

9. What would improve the current instruction set?

10. Do you think the (gray) supports help visitors construct a better bridge?
(Please explain why or why not)

APPENDIX D: TURNTABLE OBSERVATION FORM



APPENDIX E: TURNTABLE OBSERVATION KEY

Only visitors that appeared to be between the ages of 8 -14 are to be observed. If not indicated otherwise use “X” for “Yes” and “-“ for “No”. Mark all fields that apply.

General Profile Section

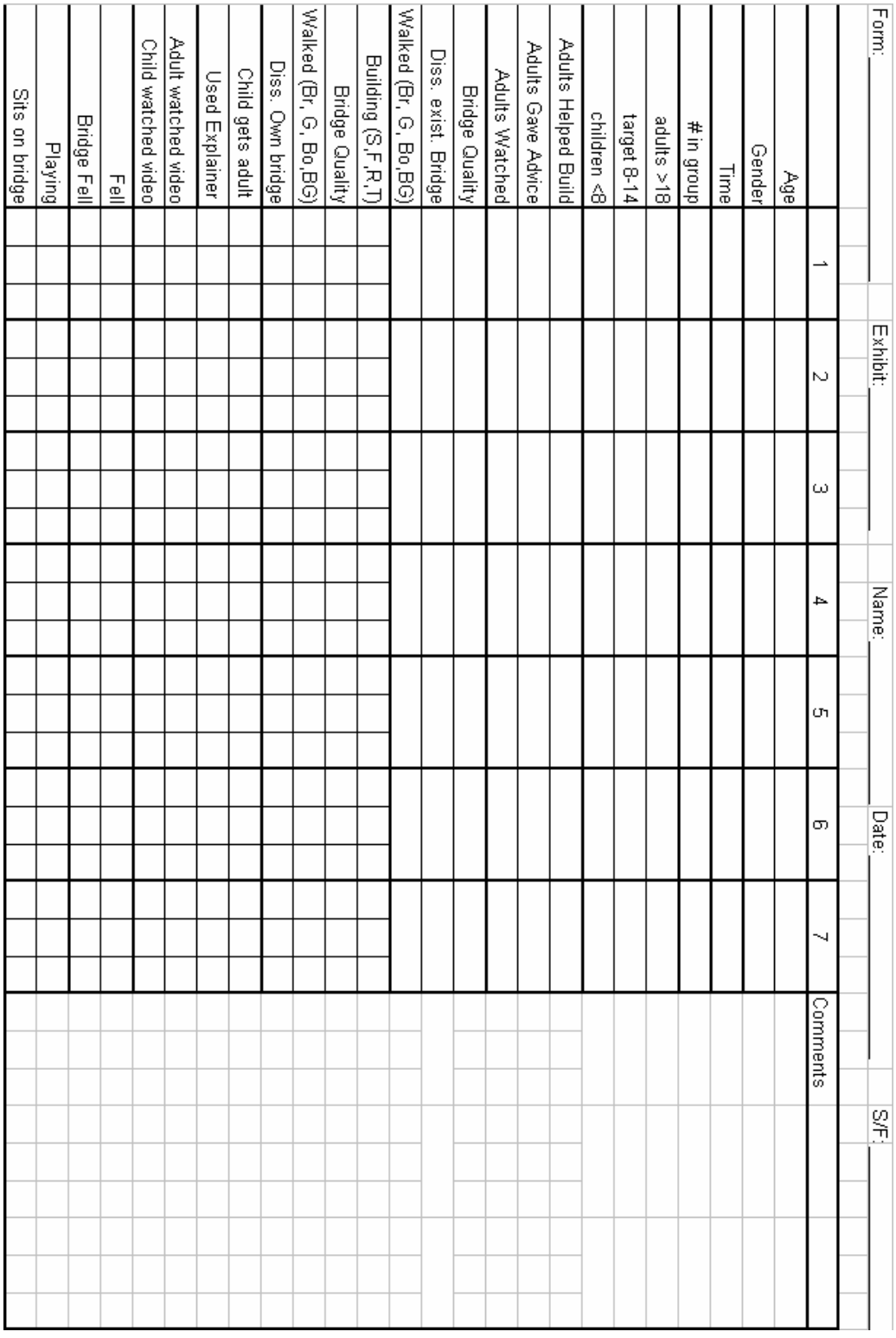
Field Name	Description
Age	Estimated age of the visitor, answer should be an integer.
Gender	Visitors Gender, answer should be M or F, indicating male or female.
Adult Help	If an adult helped the visitor by giving verbal instructions, signaling, demonstrating, or giving the visitor a push then put an X in the box. If no adult help was observed put a “–“ in the box
Used Explainer	If an explainer helped the visitor by giving verbal instructions, signaling, demonstrating, or giving the visitor a push then put an X in the box. If no explainer help was observed put a horizontal line in the box
Time	Time in seconds from when the visitor first stepped onto the spinning platform (not right when they step in the ring) to when they stepped off of the spinning platform

Interaction Section

Field Name	Description
Too Brief	Less than 10 second total interaction time
Copied Prev Visitor	If several visitors are on the elevated platform taking turns on the Turntable, each repeating the same *incorrect* behavior. Also if a visitor in line repeats the same *incorrect* behavior as the previous visitor.
Used Feet to Speed Up	If a visitor started the platform spinning by using their feet more than three times in a single continuous interaction
Remained Motionless	If a visitor is spinning slower than one rotation in 5 seconds, or if they stand motionless on the platform for a period greater than 5 seconds.
Fell	If a visitor stumbled off of the spinning platform onto the ground with at least one foot. Also if a visitor fell completely on to the ground.
Only leaned Out	If a visitor did not change position from leaning out beyond the plane of the spinning platform for the entire interaction, or for a period of approx. 12 seconds or greater. Which ever occurs first.
Only Leaned In	If a visitor did not change position from leaning inside the plane of the spinning platform for the entire interaction, or for a period of approx. 12 seconds or greater. Which ever occurs first.
Sat Down	If the visitor sat on the spinning platform at any time during the interaction.
Controlled Speed	If the visitor was able to make themselves go visibly faster or slower by changing positions without immediately falling.

Leaned In and Out	If a visitor leaned in, and then out again. Also if a visitor leaned out, then back in.
Started Leaning Back	If a visitor started out leaning beyond the plane of the spinning platform.
Pointed to Instructions	If a visitor points something out on the instructions to a parent, explainer, friend, or teacher.
Demonstrated Concept	If the visitor is observed talking about the concept, or signaling about the concept to a parent, explainer, friend, or teacher.

APPENDIX F: ARCH BRIDGE OBSERVATION FORM



APPENDIX G: ARCH BRIDGE OBSERVATION KEY

Arch Bridge is typically used by groups of people rather than individuals. Therefore it will be important to gather data not only about the subject, but about the entire group. To gather data about more than one visitor at a time it will be necessary to focus on one individual to record time, age, and gender, but at the same time observe the actions of the entire group.
Only groups that contain visitors with a least one child in the age range will be observed.
The supports will not be used when testing Arch Bridge.
If not indicated otherwise use "X" for "Yes" and "-" for "No". Mark all fields that apply.

General Profile Section

Field Name	**Description**
Time	To get the time start the stopwatch when the subject first enters the black pad on the ground around arch bridge or is obviously watching the video (See "Adult watched video" for further explanation). Stop the watch when the subject leaves along with most of the group. Mark the time in seconds
Age	Estimated age of the visitor.
Gender	Visitors Gender, answer should be M or F.
# in group	Number of people who are clearly a part of the group with the subject initially. When group size changes during interacting note this down by adding I's to the three sections below
Adults > 18	Number of legal adults
Target 8-14	Number of children in the age range
Children < 8	Number of visitors who fall below the age range

Interaction Section

Field Name	**Description**
Adults help build	If an adult(s) present helps build the bridge. This means they must actually contact at least one of the red stones.
Adults gave advice	If the adult(s) present give verbal advice about how to construct the bridge, or carry on a conversation about the exhibit with the subject. This can occur at the same time the adult(s) are helping to build the bridge.
Adults Watched	If the adult(s) present does not offer any verbal or physical help to the subject. This option should be accounted for if neither of the above are checked.
Bridge Quality	Evaluate the quality of the bridge that the subject approaches on a scale of 1 to 5. (See Figure 36 to Figure 40)
Diss. Exist. Bridge	Did the subject take the already existing bridge apart? If any rearrangements to the existing bridge are made then yes.

Walked	Evaluate the walking portion of the subject's interaction for previously built bridge. If they did walk across the bridge then: Br = walked on the bridge the entire time (red stones) G = Walked on the black guide the entire time Bo = Walked on a combination of both the bridge and the guide BG = Walked on blocks set on guide
Building	Evaluate the subjects building interaction. S = Started F= Finished R = Rearranged blocks T = Tried to build on top of guide
Bridge Quality	Evaluate the quality of the bridge that the subject built on a scale of 1 to 5. (See Figure 36 to Figure 40)
Walked	Evaluate the walking portion of the subject's interaction for own built bridge. If they did walk across the bridge then: Br = walked on the bridge the entire time (red stones) G = Walked on the black guide the entire time Bo = Walked on a combination of both the bridge and the guide BG = Walked on blocks set on guide
Diss. Own Bridge	The subject completely took apart their own bridge.
Child gets adult	If a child visits the exhibit, leaves, and returns with an adult(s). Also if the child calls to the adult(s) to approach rather than leaving the exhibit.
Used Explainer	If an explainer helped the visitor by giving verbal instructions, signaling, demonstrating, or helping the visitor to install a block then put an X in the box. If no explainer help was observed put a horizontal line in the box
Adult watched video	If adult present and video label present and adult watched video in a manner obvious to the observer (e.g. staring at screen for longer than 10 seconds, holding the monitor while looking at it, pointing at the video)
Child watched video	If the observed child is watching the video label in a manner obvious to the observer (e.g. staring at screen for longer than 10 seconds, holding the monitor while looking at it, pointing at the video)
Fell	If a subject falls off of the bridge. Purposely jumping off of the bridge is not an example of this behavior.
Bridge Fell	If the bridge that the subject is walking on falls down with out anyone talking it apart.
Playing	If a subject is using the exhibit to play around with blocks rather than building a bridge, taking a bridge apart, or walking on a bridge.
Sits on bridge	If a subject sits or crawls on a bridge rather than walking across.

Bridge Quality Examples:

Figure 36: Arch Bridge, Grade 5 Example

Figure 37: Arch Bridge, Grade 4 Example

Figure 39: Arch Bridge, Grade 3 Example

Figure 38: Arch Bridge, Grade 2 Example

Figure 40: Arch Bridge, Grade 1 Example

Grade	Description
5	Perfect. All the blocks line up evenly.
4	One brick is slightly out of place
3	More than one brick is out of place, or one brick is very out of place (less than 5 inches)
2	One brick is seriously out of place. This will probably not hold up if someone puts weight on it
1	This is an insurance liability. If some poor child walks on this they will most likely die

APPENDIX H: TURNTABLE INTERVIEW FORM

Break ice while walking with child by asking if they're having fun today.

Hello, my name is……. I work here at the Science Museum. We are interested in finding out what people think about the Turntable exhibit. Would you mind answering a few questions for us? It will only take a few minutes.

I would just like you to know that I didn't make the exhibit and will not be upset by anything you say about it, good or bad. There are no wrong answers and we can use whatever information you give us.

1. Can you tell me a little bit about what you were doing at the turntable? Can you talk me through what you did?
   - ☐ *Probe*: I noticed that you were also doing … What were you thinking when you did that?
   - ☐ *Probe*: Was there anything that helped you know how to do that?*
2. What do you think the turntable is trying to show people?
   - ☐ *Prompt*: How would you explain the turntable to someone else?*
   - ☐ *Prompt*: How would you describe it to your parents?
3. Can you tell me how you controlled your speed on the turntable?
   - ☐ *Prompt*: How did you make yourself go faster or slower? *
4. Was there anything confusing about the turntable?
   - ☐ *Probe*: What was confusing about it?
5. What exactly did you like about the turntable?
   - ☐ *Probe*: Can you tell me a little more about that?
6. What exactly did you dislike about the turntable?
   - ☐ *Probe*: Can you tell me a little more about that?
7. If you were in charge, how would you make turntable better?
   - ☐ *Probe*: Can you tell me a little more about that?
8. Did you notice the label on the turntable?

☐ *Probe*: When did you notice it? When you first approached? When you used the exhibit? Or after you used the exhibit? *

☐ *Probe*: Did you read the instructions? *

Go to question 10 if they did not notice the label

9. Did you notice the picture on the label for turntable?
   ☐ *Probe*: What was the picture of?
   ☐ *Probe*: Why do you think we put that picture there?
   ☐ *Probe*: Does it relate to what you were doing?

10. Did you ask an adult for any help using the turntable?
    ☐ *Probe*: Was it an explainer or a parent or teacher? *

11. Is there anything else you have to say about the turntable?

12. Finally, how old are you?

Thank you for your help.

Hand out sticker

Date: Time: M / F

Circle categories:

School Day Weekend/Holiday School Group Family Group

Comments and Gallery Notes:

*: always ask these prompts and probes. Ask other prompts and probes when interviewee does not give enough information.

APPENDIX I: SURVEY PROBLEMS/TIPS

General Problems:[49]

1. People try to "look good," to give good impressions.
2. People often try to please you, to give you what they think you want.
3. People sometimes try to screw you, mislead you, or put you on.
4. People try to figure things out, look for what you are after.
5. People often try to play an "appropriate" part (role selection), rather than being fully themselves.
6. People may suddenly come to see the researcher as a researcher (loss of trust), which can feel like suddenly realizing you have no clothes on.
7. People sometimes like to be looked at, and will act to retain that attention (the Hawthorne effect).
8. People have prejudices about the researcher, the psychologist, the sociologist, the academician, the college student....
9. Emotional involvement on the part of the researcher alters subjects' behaviors.
10. On the other hand, cool rationality on the part of the researcher does the same.
11. Feelings (love, hate) towards particular people can "blinker" us towards or away from their perceptions.
12. Researchers sometimes "go native," and total involvement means no more researchers.
13. We can alienate some subjects while mediating conflicts or giving advice.
14. We can turn off some subjects by associating with authorities.
15. Different cultures have different rules of exclusiveness regarding sex, age, and so on.

General Tips:

1. Practice observing with others on the research team to be sure that the same things are being observed and recorded in a consistent manner.
2. Put full attention on what you are observing.
3. Do not draw attention to yourself.

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[49] Exploring Exhibit Extension at the Science Museum, London, UK. WPI Interactive Qualifying Project C Term 2006. http://www.wpi.edu/~lsm, Final Proposal Appendix C

4. Write detailed field notes. Describe what you see and also note the hunches or ideas that come to you while you're observing.
5. When in doubt, invite other members of the team to observe and offer suggestions.
6. Analysis and reporting begin with a brief statement of the problem that gave rise to the study. Write a paragraph describing how the study was conducted. In this paragraph describe the situation, environment, timing of observation, research team, subjects, etc.
7. Analysis can be in several forms. Aggregate the results if you are using a checklist. Look over your field notes. Look for patterns, themes, or overarching concepts. Draw sketches of concepts or relationships. Draw a picture of force fields or flow charts or time lines, etc. to illustrate the concepts.

APPENDIX J: SUMMARY FOR SECTION 3.1

	Goal	**Methods**
	The goal for this portion of the study	How we will collect the data
Surveying explainers	1. Get feedback about the nature of the exhibit 2. Identify what scientific concept the exhibit is supposed to convey 3. Identify problems with the current set of instructions (text label)	Distribute printed survey to explainers and collect filled out surveys a week after distribution
Observing visitors	1. Identify visitors' behavior and common usage of exhibit 2. Obtain quantitative statistical data about interaction with exhibit	Using pre-coded form, checking off features of visitors' behaviors for target audience
Interviewing visitors	1. Find out whether visitors understand concept of exhibit 2. Find out whether visitors noticed instruction set 3. Obtain qualitative statistical data about interaction with exhibit	1. Selecting every third observed visitor 2. Using fixed set of questions, probes and prompts 3. One person asking question, one person noting down answers

	Analysis	**Outcome**
	How we will analyze the data	How our analysis will be expressed
Surveying explainers	1. Descriptive statistics for grading questions 2. Group answers to open question to get common answers	1. Descriptive graphs to display results (averages) of grading questions 2. Bullet point list of common answers to open question
Observing visitors	1. Descriptive statistics to identify trends 2. Quantitative statistics to test hypothesis' 3. Find relations to qualitative data from interviews to support hypothesis	Descriptive graphs to illustrate trends in observed data using diversity of graphs and numerical tables
Interviewing visitors	1. Encoding of questions 2. Qualitative analysis of answers by finding relations to observed trends	If applicable numerical tables and descriptive graphs

APPENDIX K: CONTENT FOR VIDEO LABELS

Phase 1 – The Instructions:

- The video's instructional part has to be short enough to not lose the visitor's attention. Two minutes should be sufficient to explain the exhibit in detail but at the same time be short enough to keep the visitor's attention. However, it must not present the instructions in a way that it hurries over the steps.
- Because each visitor will probably see the instructions only once, is it necessary to present the instructions clearly and in a way that they are easy to follow.
- The video's instructional part should include footage of persons (e.g. explainers) who are using the exhibit correctly.
- Comprehensible (simplified) diagrams should be used to present certain mechanisms.
- Where mechanisms cannot be simplified to diagrams, video footage could be used.
- Phase 1 must be balanced between given clear instruction for a successful use of the exhibit and encouraging experimentation.
- Should include an introduction to the subject matter that the exhibit demonstrates.
- The introduction should be comprehensible (non-mathematical) and not require any background knowledge.
- The conceptual part has the highest potential to lose attention, because it will explain the scientific background. The introduction should therefore be short.
- If possible something similar to a popular cartoon character could be used to make the introduction less intimidating and more attractive to children.

Phase 2 – Real Life Applications:

- The real life applications and example should not rely on Phase 1 in explaining how the concept applies to real life. Instead, it should rely on the exhibit itself or the example should be easily understandable to children.
- The examples should be applicable to children not adults.
- The examples could either demonstrate the concept in an obvious fashion or could be used to trigger interest in the sense that the application is not easily recognized. Then an

easy to follow explanation should be used to demonstrate the relation between example and exhibit.

General Content Concepts:

- The phases have to be independent of each other and self explanatory. Because the visitor might approach the exhibit at any time and therefore no phase can depend on knowledge of a previous phase.
- The video should be short so that visitors might consider watching it again. A lengthy video will prevent this.
- The video's sound must be loud enough to be heard when watching the video from several feet away. But the volume of a video should not be annoying to a visitor. The video must attract visually, not audibly.
- All three phases of the video have to be detailed enough to be educational for children without any background knowledge. However, they must not be boring!
- The instructional part of the video should be detailed, but the examples of real life applications should be general and easily understandable.
- The transitions between phases must be short and smooth. They should offer a clear cut between the phases. An opening graphic can be used to introduce a phase and state its goals. A similar graphic at the end of a phase could restate the goals.
- The video should be narrated and include subtitles to ensure understanding even if video cannot be heard.

APPENDIX L: SLIDE SHOW FOR TURNTABLE

Figure 41: Turntable Slideshow, Slide 1

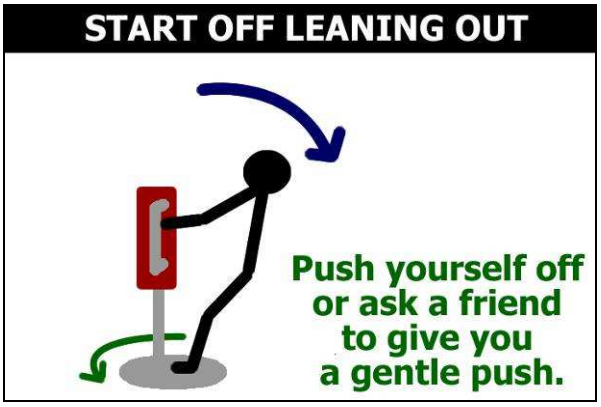


Figure 42: Turntable Slideshow, Slide 2

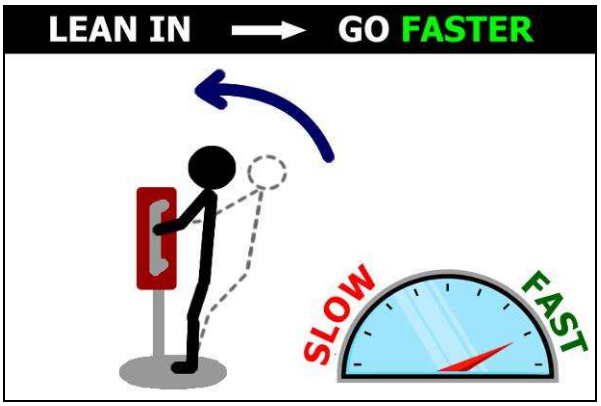


Figure 43: Turntable Slideshow, Slide 3

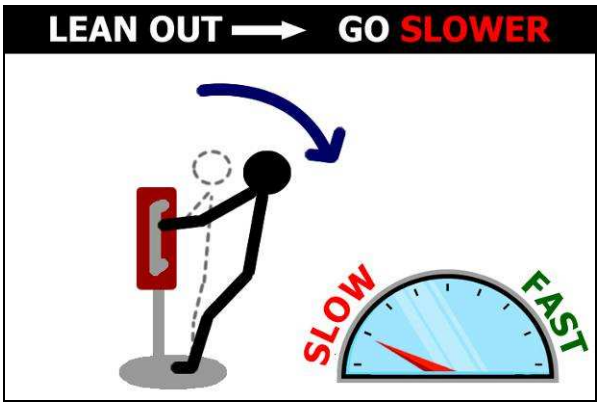
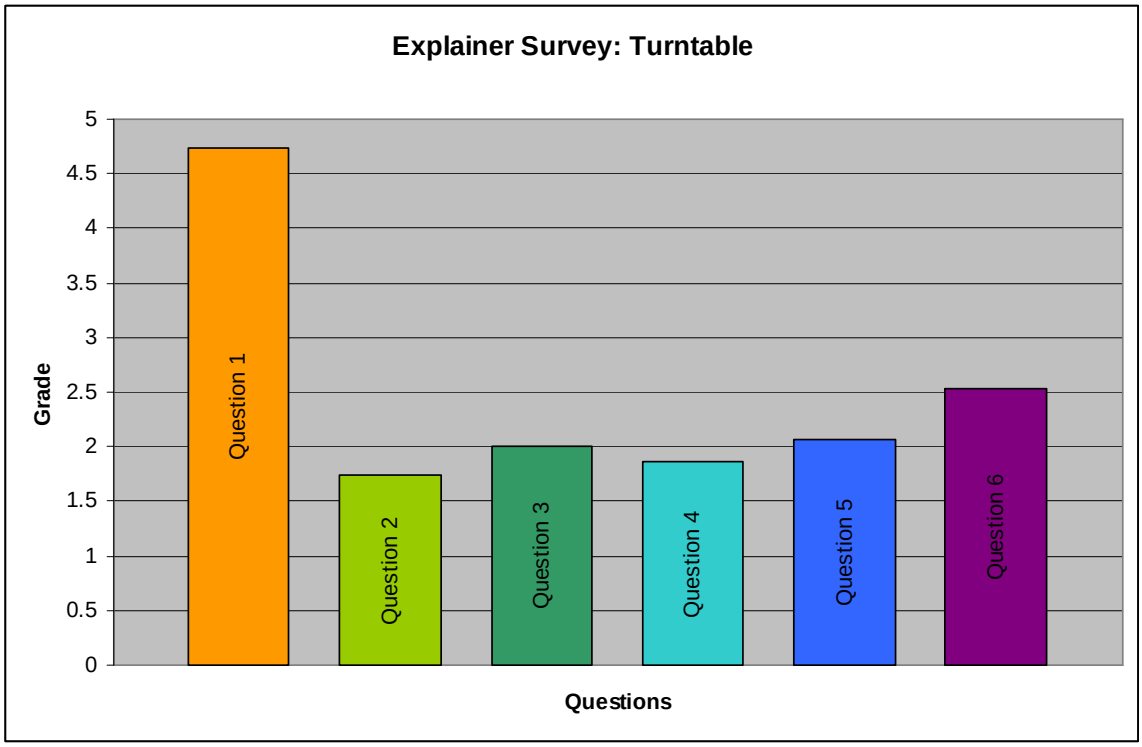


Figure 44: Turntable Slideshow, Slide 4

APPENDIX M: RESULTS FOR EXPLAINER SURVEY FOR TURNTABLE

Results for Questions 1 to 6:



Answers to Questions 7 to 9:

Question 7

- Not visually attractive enough
- Needs more visual aids, language impediment for foreigners or young children
- Does not communicate science in accessible way (usage of specific terms like “angular momentum”)
- Not as effective as explainer
- Missing sound
- Should separate instructions from conceptual explanations
- Placed too high, eye-level for adults

Question 8

- Scientific principles are not conveyed successfully

- No link between instructions and experience of spinning, controlling speed with your own weight
- Text label not sufficient to explain scientific concept
- Too much text on label, not visual enough
- No step by step guide
- Does not draw attention

Question 9

- Make instruction set more attractive
    - add pictures and/or videos for instructions (step by step)
    - add visuals to explain concept
    - Add screen that shows visitor using Turntable
    - Add sound effects
- Place it on eye-level for children of age 8-14 years
- Place it so it is visible while using Turntable
- Make language more accessible, bullet point explanations

APPENDIX N: TURNTABLE VIDEO SCREENSHOTS

Figure 45: Turntable Video Screenshot 1

Figure 46: Turntable Video Screenshot 2

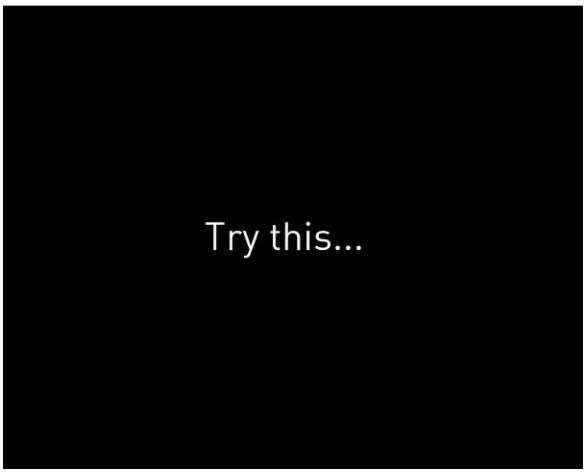


Figure 47: Turntable Video Screenshot 3

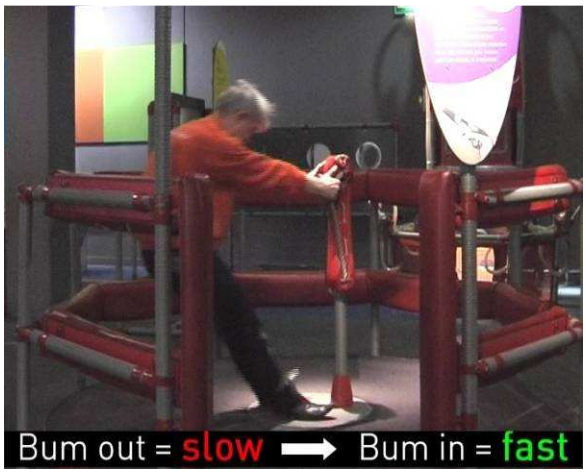


Figure 48: Turntable Video Screenshot 4

Figure 49: Turntable Video Screenshot 5

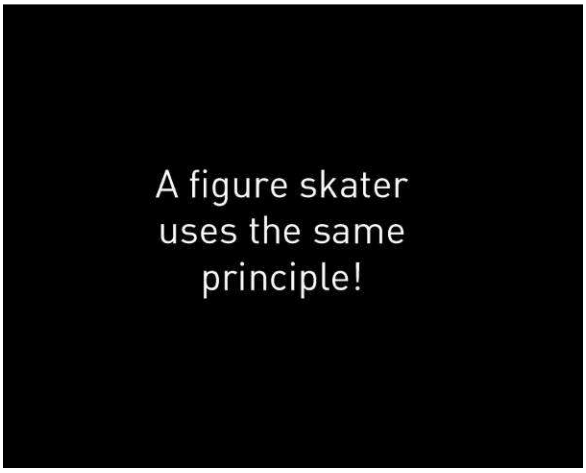


Figure 50: Turntable Video Screenshot 6

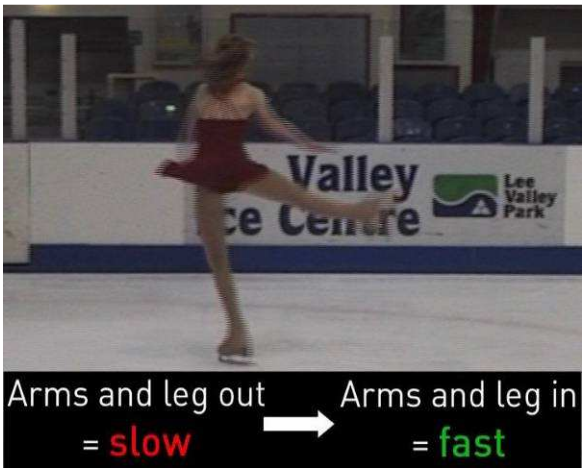


Figure 51: Turntable Video Screenshot 7

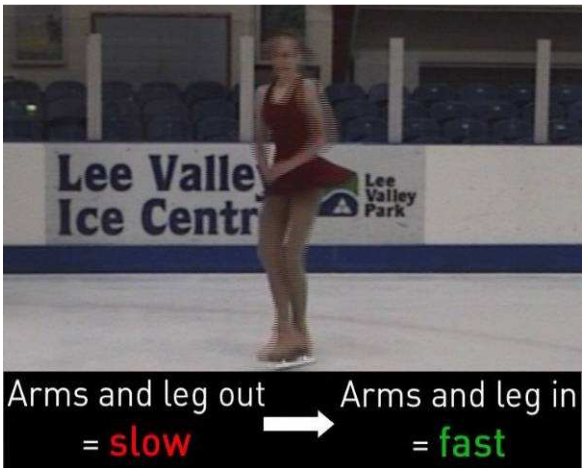
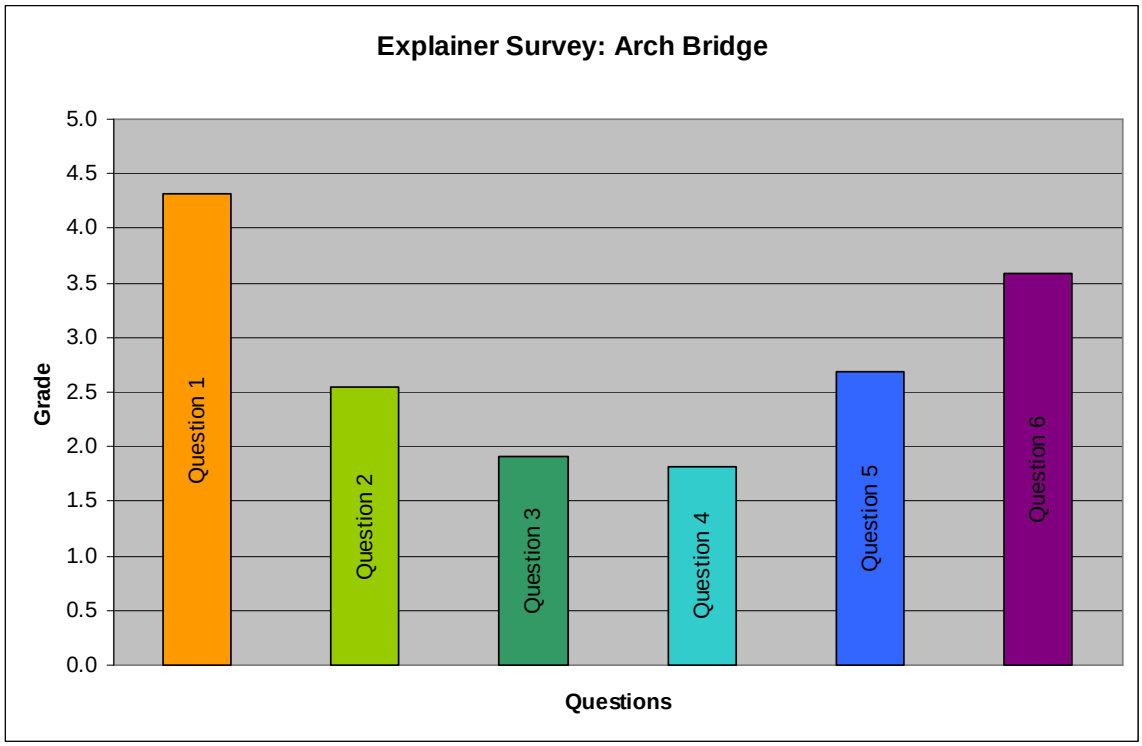


Figure 52: Turntable Video Screenshot 8

APPENDIX O: RESULTS FOR EXPLAINER SURVEY FOR ARCH BRIDGE

Results for Questions 1 to 6:



Answers to Questions 7 to 9:

Question 7

- Visuals aids are needed (e.g. diagrams)
- Not attractive enough, no one notices them, boring
- Not accessible
- Lacks specific detail, does not talk about the wedge form
- Not obvious enough
- Instructions are poorly placed (e.g. too far away from blocks)

Question 8

- Missing visual aids (e.g. diagrams)
- Children don't see the text label
- Not enough detailed description

- Most young children that use the exhibit need the assistance of an adult to do so successfully

Question 9

- Add visual aids (e.g. diagrams or better pictures)
- Bolder text
- More interesting, fun
- More prominent place (e.g. closer to exhibit)
- More clearly phrased points (e.g. What exhibit is, how to do it, what it shows)
- Have science be suitable for age of visitor who use exhibit
- Make it clear that you need to let blocks fall into place
- Explain wedge form
- Extension might help increase understanding
- Add diagram of arch bridge where order of blocks numbered

Question 10

- Yes, supports are good guide
- Yes, otherwise misunderstanding about black guide in the back
- Yes, indicates shape of bridge
- Yes, allows one person to finish bridge
- Yes, because blocks are too heavy for kids
- Yes, but black guide in back is confusing
- Yes, but it is important that visitors realize to remove them when built bridge
- Yes, because after removing the supports it highlights that bridge holds without them
- No, children still need to manipulate blocks to fit in keystone
- No, because it is difficult to wedge the blocks in with supports

APPENDIX P: ARCH BRIDGE VIDEO SCREENSHOTS

Figure 53: Arch Bridge Video Screenshot 1

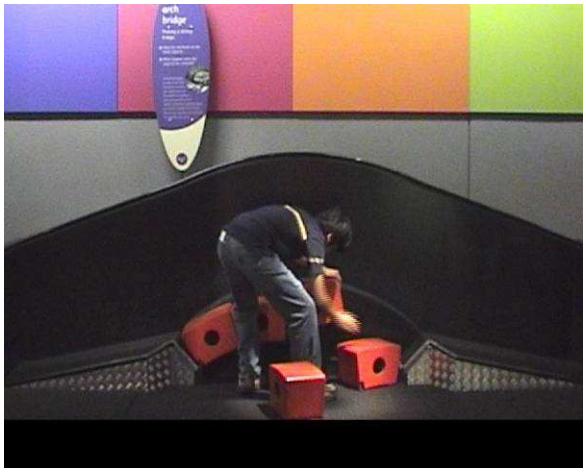


Figure 54: Arch Bridge Video Screenshot 2

Figure 55: Arch Bridge Video Screenshot 3

Figure 56: Arch Bridge Video Screenshot 4

Figure 57: Arch Bridge Video Screenshot 5

Figure 58: Arch Bridge Video Screenshot 6

Figure 59: Arch Bridge Video Screenshot 7

Figure 60: Arch Bridge Video Screenshot 8

APPENDIX Q: SUMMARY FOR SECTION 3.2

	Goal	**Methods**
	The goal for this portion of the study	How we will collect the data
Identify content for visual instructions	Find content that is needed to remedy identified problems with exhibit	1. Consider results from explainer survey 2. Informal interviews with visitor research department about exhibit
Obtain needed footage	Make needed content available for video label	1. Make use of camera and do filming personally 2. Find free footage online
Create video	Produce label that aims at solving identified problems	Stream clips together using Adobe Premiere Elements
Place label on gallery	Prototype video label and obtain survey data	1. Use housing for protection if needed 2. Place prototype safely to not generate possible hazards for visitors

	Outcome
	How our analysis will be expressed
Identify content for visual instructions	Outline of plot for video label
Obtain needed footage	Video footage needed for video label
Create video	Video label ready for prototyping
Place label on gallery	Survey data to analyze visitors' behavior

APPENDIX R: NMSI RISK ASSESSMENT FORM

NMSI Risk Assessment Form

Nature / type of task being assessed and location/s					
Date of Assessment		Date by when assessment must be reviewed		Assessment Completed by / Department	
How many people could be at risk?		What category of person may be at risk (e.g. employee, contractor, public, young, old, special needs?)			

Hazard / risk	Conse- quence	Likeli hood	Score C x L	Risk rating	Action/solution	Time scale	✓

assessment values		classification of risk rating (C x L = score)		action from risk rating	
consequence (C)	likelihood (L)	score	risk rating	action	time scale
Marginal - 1 (slight injury, minor first aid)	unlikely - 1	1	Trivial	No further action required	-
		2	Tolerable	Keep control measures under review	within 3 months
Dangerous - 2 (serious injury or damage)	likely - 2 (to occur at some time)	3-4	Moderate	Fine tune control measures	within 3 months
Very dangerous - 3 (could cause death or widespread injuries)	very likely - 3	6	Substantial	Urgent control measures needed	within 1 month
		9	Intolerable	Stop activity until risk reduced	immediately

- Your assessment will need to consider who and how many people may be affected by the hazard/s – ie children or the elderly may be most at risk. In these circumstances the risk rating will need to reflect this.
- Where the activity or task is a one off event – the 'time scales for action' may need to be amended to ensure that safety controls are implemented before the activity takes place.
- Please remember you are not expected to risk assess activities that are outside of you knowledge, expertise or experience.
- Further information and assistance can be obtained from the NMSI Health & Safety Advisor.

Remember

Hazard means anything that can cause harm.

Risk is the chance, high or low that somebody will be harmed by the hazard

Five Steps to Risk Assessment

- Look for the hazards
- Decide who might be harmed
- Evaluate the risks and decide whether the existing precautions are adequate or whether more should be done
- Record your findings.
- Review your assessment and revise it if necessary

APPENDIX S: TURNTABLE VIDEO LABEL INTERVIEW FORM

Break ice while walking with child by asking if they're having fun today.

Hello, my name is……. I work here at the Science Museum. We are interested in finding out what people think about the Turntable exhibit. Would you mind answering a few questions for us? It will only take a few minutes.

I would just like you to know that I didn't make the exhibit and will not be upset by anything you say about it, good or bad. There are no wrong answers and we can use whatever information you give us.

13. Can you tell me a little bit about what you were doing at the turntable? Can you talk me through what you did?
    - ☐ *Probe*: I noticed that you were also doing … What were you thinking when you did that?
    - ☐ *Probe*: Was there anything that helped you know how to do that?*

14. What do you think the turntable is trying to show people?
    - ☐ *Prompt*: How would you explain the Turntable to someone else?*
    - ☐ *Prompt*: How would you describe it to your parents?

15. Can you tell me how you controlled your speed on the turntable?
    - ☐ *Prompt*: How did you make yourself go faster or slower?*

16. Was there anything confusing about the turntable?
    - ☐ *Probe*: What was confusing about it?

17. What exactly did you like about the turntable?
    - ☐ *Probe*: Can you tell me a little more about that?

18. What exactly did you dislike about the turntable?
    - ☐ *Probe*: Can you tell me a little more about that?

19. If you were in charge, how would you make the turntable better?
    - ☐ *Probe*: Can you tell me a little more about that?

20. Did you notice the video next to the turntable?
    - ☐ showed picture to child
    - ☐ *Probe*: When did you notice it? When you first approached? When you used the exhibit? Or after you used the exhibit?*

☐ *Probe*: Did you watch the instructions part?*

Go to question 16 if they did not notice the video

21. What do you think the video label was trying to show?
    ☐ *Probe*: Why do you say that?

22. What was the man in the video doing?
    ☐ *Probe*: How did he do that?

23. Did you notice the ice skater in the video?
    ☐ *Probe*: Why do you think we put the ice skater in the video?
    ☐ *Probe*: How does it relate to what you were doing?

24. Was there anything confusing or difficult to understand in the video?

25. What did you like about the video?
    ☐ *Probe*: Can you tell me a little more about that?

26. What did you dislike about the video?
    ☐ *Probe*: Can you tell me a little more about that?

27. Why do you think we put the video there?

28. Did you ask an adult for any help using the Turntable?
    ☐ *Probe*: Was it an explainer or a parent or teacher?*

29. Is there anything else you have to say about the Turntable?

30. Finally, how old are you?

Thank you for your help.

Hand out sticker

Date: Time: M / F

Circle categories:

School Day Weekend/Holiday School Group Family Group

Comments and Gallery Notes:

*: always ask these probes and prompts. Ask other prompts and probes when interviewee is not giving enough information.

APPENDIX T: TURNTABLE SLIDE SHOW LABEL INTERVIEW FORM

Break ice while walking with child by asking if they're having fun today.

Hello, my name is……. I work here at the Science Museum. We are interested in finding out what people think about the Turntable exhibit. Would you mind answering a few questions for us? It will only take a few minutes.

I would just like you to know that I didn't make the turntable exhibit and will not be upset by anything you say about it, good or bad. There are no wrong answers and we can use whatever information you give us.

31. Can you tell me a little bit about what you were doing at the turntable? Can you talk me through what you did?
    - ☐ *Probe*: I noticed that you were also doing … What were you thinking when you did that?
    - ☐ *Probe*: Was there anything that helped you know how to do that? *

32. What do you think the turntable is trying to show people?
    - ☐ *Prompt*: How would you explain this exhibit to someone else?*
    - ☐ *Prompt*: How would you describe it to your parents?

33. Can you tell me how you controlled your speed on the turntable?
    - ☐ *Prompt*: How did you make yourself go faster or slower? *

34. Was there anything confusing about the turntable?
    - ☐ *Probe*: What was confusing about it?

35. What exactly did you like about the turntable?
    - ☐ *Probe*: Can you tell me a little more about that?

36. What exactly did you dislike about the turntable?
    - ☐ *Probe*: Can you tell me a little more about that?

37. If you were in charge, how would you make the turntable better?
    - ☐ *Probe*: Can you tell me a little more about that?

38. Did you notice the slideshow label next to the turntable?

☐ showed picture to child

☐ *Probe*: When did you notice it? When you first approached? When you used the exhibit? Or after you used the exhibit? *

☐ *Probe*: Did you watch the instructions part? *

Go to question 14 if they did not notice the slideshow

39. What do you think the slideshow label was trying to show?

☐ *Probe*: Why do you say that?

40. Was there anything confusing about the slideshow label?

☐ *Probe*: Can you tell me a little more about that?

41. What did you like about the slideshow label?

☐ *Probe*: Can you tell me a little more about that?

42. What did you dislike about the slideshow label?

☐ *Probe*: Can you tell me a little more about that?

43. Why do you think we put the slideshow label there?

44. Did you ask an adult for any help using the turntable?

☐ *Probe*: Was it an explainer or a parent or teacher? *

45. Is there anything else you have to say about the turntable?

46. Finally, how old are you?

Thank you for your help.

Hand out sticker

Date: Time: M / F

Circle categories:

School Day Weekend/Holiday School Group Family Group

Comments and Gallery Notes:

*: always ask these prompts and probes. Ask other probes and prompts when interviewee does not give enough information.

APPENDIX U: CODING SHEET BEFORE CHANGES

Base all coding on answers to interview questions only, do not take observations into account. Each interview may have more than one code in each section.

Use- Look at questions: 1, 2, 3, 4, 5, 6, 7, 10

Successful

U1: Completely connected leaning with speed (explicitly stating something to the effect of "lean in = fast, lean out = slow") and stated that you have to start leaning out

U2: Completely connected leaning with speed (explicitly stating something to the effect of "lean in = fast, lean out = slow")

U3: Stated that you have to start leaning out

U4: Incompletely connected leaning with speed change (stated either lean in = fast OR lean out = slow)

Unsuccessful

U5: Stated that leaning out makes you go faster and leaning in makes you go slower (opposite of correct)

U6: Controlled speed incorrectly (something other then leaning in and out)

U7: Had someone else push to go faster (after initial start)

U8: Controlled speed with the foot (after initial start)

U9: Just tried to go as fast as possible (without at all investigating the leaning effects)

U10: Couldn't get turntable started

U11: Related turntable to only playing around

Concept- Look at question: 2, (9)

Successful

C1: Mentioned angular momentum and / or moment of inertia

C2: Mentioned momentum

C3: Stated that the exhibit illustrates the relation (and described the relation correctly and completely) of distance from center (circle size, etc.) and speed (ex. The closer you are the faster you go)

C4: Stated that the exhibit illustrates the relation (but described the relation incorrectly and / or incompletely) of distance from center (circle size, etc.) to speed (ex. When you are closer you go slower)

C5: Stated that the exhibit is about Energy or Forces

Unsuccessful

C6: Stated that the exhibit is about Gravity, G-Force, other Forces

C7: Stated that the exhibit is about getting Dizzy

C8: Other incorrect explanation of the exhibit's purpose

Real Life Ties- Look at question: 9

Successful

R1: Noticed picture, identified as skater, related to angular momentum

R2: Noticed picture, identified as skater, related to what they were doing (weight in and out)

R3: Noticed picture, identified as skater but couldn't relate correctly

R4: Noticed picture, identified as person similar to skater (i.e., ballerina)

Unsuccessful

R5: Noticed picture, identified as someone completely different from skater

R6: Noticed picture, couldn't identify person

R7: Did not notice picture

Label- Look at questions: 1, 4, 5, 6, 7, 8, 9

Successful

L1: Noticed and read entire label before using exhibit

L2: Noticed and read part of label before using exhibit

L3: Noticed and read entire label after using exhibit

L4: Noticed and read part of label after using exhibit

Unsuccessful

L5: Noticed label but did not read

L6: Did not notice label

APPENDIX V: CODING SHEET FOR SLIDE SHOW LABEL

Base all coding on answers to interview questions only, do not take observations into account. Each interview may have more than one code in each section.

Use- Look at questions: 1, 2, 3, 4, 5, 6, 7, 14

Successful

U1: Completely connected leaning with speed (explicitly stating something to the effect of "lean in = fast, lean out = slow") and stated that you have to start leaning out

U2: Completely connected leaning with speed (explicitly stating something to the effect of "lean in = fast, lean out = slow")

U3: Stated that you have to start leaning out

U4: Incompletely connected leaning with speed change (stated either lean in = fast OR lean out = slow)

Unsuccessful

U5: Stated that leaning out makes you go faster and leaning in makes you go slower (opposite)

U6: Controlled speed incorrectly

U7: Had someone else push to go faster (after initial start)

U8: Controlled speed with foot (after initial start)

U9: Just tried to go as fast as possible (without at all investigating the leaning effects)

U10: Couldn't get turntable started

U11: Related turntable to playing around

Concept- Look at questions: 2, 9, 13

Successful

C1: Mentioned angular momentum and / or moment of inertia

C2: Mentioned momentum

C3: Stated that the exhibit illustrates the relation (and described the relation correctly and completely) of distance from center (circle size, etc.) and speed

C4: Stated that the exhibit illustrates the relation (but described the relation incorrectly and / or incompletely) of distance from center (circle size, etc.) to speed

C5: Stated that the exhibit is about Energy or Forces

Unsuccessful

C6: Stated that the exhibit is about Gravity, G-Force, other Forces

C7: Stated that the exhibit is about getting Dizzy

C8: Other incorrect explanation of the exhibit's purpose

Label- Look at questions: 1, 5, 6, 7, 8, 9, 10, 11, 12, 13

Successful

L1: Noticed and watched slideshow before using exhibit and correctly relayed content of slideshow

L2: Noticed and watched entire slideshow before using exhibit but could not relay content

L3: Noticed and watched part of slideshow before using exhibit

L4: Noticed and watched entire slideshow after using exhibit and correctly relayed content of slideshow

L5: Noticed and watched entire slideshow after using exhibit but could not relay content

L6: Noticed and watched part of slideshow after using exhibit

L7: Did not notice slideshow label but noticed and read text label

L8: Did not notice slideshow but noticed and read part of text label

Unsuccessful

L9: Noticed slideshow but did not watch

L10: Did not notice slideshow but noticed text label (did not read)

L11: Did not notice slideshow or text label

APPENDIX W: CODING SHEET FOR VIDEO LABEL

Base all coding on answers to interview questions only, do not take observations into account. Each interview may have more than one code in each section.

Use- Look at questions: 1, 2, 3, 4, 5, 6, 7, 16

Successful

U1: Completely connected leaning with speed (explicitly stating something to the effect of "lean in = fast, lean out = slow") and stated that you have to start leaning out

U2: Completely connected leaning with speed (explicitly stating something to the effect of "lean in = fast, lean out = slow")

U3: Stated that you have to start leaning out

U4: Incompletely connected leaning with speed change (stated either lean in = fast OR lean out = slow)

Unsuccessful

U5: Stated that leaning out makes you go faster and leaning in makes you go slower (opposite)

U6: Stated how to control speed incorrectly

U7: Stated that had someone else push to go faster (after initial start)

U8: Stated that controlled speed with the foot (after initial start)

U9: Just tried to go as fast as possible (without at all investigating the leaning effects)

U10: Couldn't get turntable started

U11: Related turntable to only playing around

Concept- Look at questions: 2, 9, 10, (11, 15)

Successful

C1: Mentioned angular momentum and / or moment of inertia

C2: Mentioned momentum

C3: Stated that the exhibit illustrates the relation (and described the relation correctly and completely) of distance from center (circle size, etc.) and speed

C4: Stated that the exhibit illustrates the relation (but described the relation incorrectly and / or incompletely) of distance from center (circle size, etc.) to speed

C5: Stated that the exhibit is about Energy or Forces

C6: Stated that the exhibit is about figure skating or ballet

Unsuccessful

C7: Stated that the exhibit is about Gravity, G-Force, other Forces

C8: Stated that the exhibit is about getting Dizzy

C9: Other incorrect explanation of the exhibit's purpose

Real Life Ties- Look at question: 11

Successful

R1: Watched the video of the figure skater, related to angular momentum

R2: Watched the video of the figure skater, related to what they were doing (weight in and out, or arms and leg in and out related to bum in – bum out)

R3: Watched the video of the figure skater, but couldn't relate or related incorrectly

Unsuccessful

R4: Did not watch the video of the figure skater

Label- Look at questions: 1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15

Successful

L1: Noticed and watched the video before using the exhibit and correctly relayed the content

L2: Noticed and watched the entire video before using the exhibit but could not relay the content

L3: Noticed and watched part of the video before using exhibit

L4: Noticed and watched the entire video after using the exhibit and correctly relayed the content

L5: Noticed and watched the entire video after using the exhibit but could not relay the content

L6: Noticed and watched part of the video after using the exhibit

L7: Did not notice the video but noticed and read the text label

L8: Did not notice the video but noticed and read part of text label

Unsuccessful

L9: Noticed the video but did not watch

L10: Did not notice the video but noticed the text label (but did not read it)

L11: Did not notice the video or the text label

APPENDIX X: SCHEDULE