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Increasing Interaction With Engines

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Abstract

The National Railway Museum (NRM) in York, U.K. is applying for funds in order to renovate the Great Hall. As part of the renovation, the NRM wants to increase visitor interaction with these exhibits. This project designed an engine experience for families and school children, accessible by the physically disabled. Using the methods of Active Prolonged Engagement and Life Enhancing Experience, the team designed, developed, and tested two prototype exhibits which were interactive, educational, and in accordance with the Disabled and Disabilities act. The prototype and the findings were used by the museum design team to help design new exhibits for their renovation.

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Table of Contents

List of Figures

List of Tables

Executive Summary: Interactive Engine Experience

The National Railway Museum (NRM) in York, U.K. is applying for funds in order to renovate the Great Hall. This hall, a re-purposed roundhouse, is the largest exhibit space at the museum and houses many iconic steam, diesel, and electric engines from around the world. Named NRM+, this renovation is the largest endeavor the NRM has ever partaken.

Currently, visitors to the museum can only experience the engines from ground level or from the cab. As part of the renovation, the NRM wants to increase visitor interaction with these exhibits and bring an equal engine experience to those not able to enter the cab physically. This project designed an engine experience targeted for families and school children. Using the methods of Active Prolonged Engagement and Life Enhancing Experience, the team designed and tested two prototype exhibits capable of meeting the NRM's goal.

The Active Prolonged Experience (APE) approach to creating a successful learning environment originates from research conducted at the Exploratorium, a museum located in San Francisco, USA. The study, and exhibition of the same name, divides visitor experiences into four categories: exploration, investigation, observation, and construction. A well designed APE encourages visitors to manipulate the exhibit in a way that they are encouraged to ask questions of the exhibit and investigate within the constraints of the exhibit to find the answer. Using these four techniques, visitors stay longer at an exhibit, actively think with the material given to them, and learn on their own.

Life Enhancing Experiences (LEE) is a method created by NMSI to assess the quality of visitor experience. A Life Enhancing Experience is an interactive, memorable, and educational experience which provides a connection between the exhibit and the visitor's life. A successful LEE should encourage personal connection by provoking visitors travelling with friends or family to share stories and other past experiences. LEE is a method to make exhibits more personal and enjoyable.

To assess the degree which the prototypes met the criteria, we created a matrix which clearly defined all the requirements for the prototypes and established a way to determine compliance. We created criteria from the combined requirements of LEE, APE, the Disabled and Disabilities Act, and the NRM+ renovation requirements. Using the matrix, we created two prototype exhibits which sufficiently met the requirements. We named the exhibits “I Spy” and “You're the Driver.”

“I spy” consists of two parts. First, the visitor must read clues of an object on the engine and look at a silhouette of that object. Based on the clues the visitor must walk around the engine and find the specified part of the engine. After the visitor touches the object the engine reacts with lights, sounds, and other theatrical effects. The exhibit gives information to the visitor about the part she just touched.

The other exhibit design, “You’re the Driver,” is a game in which a visitor gets to drive a simulated engine. The visitor experiments with the controls of the engine until he gets the engine to move forward down the track. This allows visitors to experience driving an engine without the complications of a full simulator. Adding more sets of controls to the exhibit would allow for visitors to compete against each other.

We prototype tested “I Spy” with visitors to the NRM against our criteria. We found that “I Spy” met all of the requirements except for education. We expected the visitor to receive most of the educational information after they had found the correct answer. During testing however, visitors ignored the information and moved on to the next question. Future versions of this prototype should experiment with including educational information within the item prompt.

We were unable to test “You’re the Driver” with visitors. From our design, we think that we met all of the criteria except for education and authenticity. Within the game, there isn’t much room for educational material and due to the simulated nature of the game, authenticity is nil. Future work with this idea should also address the shortcomings in the possibility for group involvement. As only one person could operate one set of controls at a time.

Our design ideas will help the museum transition to become more modern and engaging by replacing text panels and introducing interactive exhibits. This document includes our ideas for the NRM+ design team and our recommendations on how to develop our prototype designs further.

Chapter 1 Introduction

The National Railway Museum (NRM) in York, U.K. has recently obtained funds to undergo a complete renovation. This renovation, called NRM+, will encompass both the structure and layout of the Great Hall as well as the way visitors can experience the exhibits. The highest priority changes are those that will provide greater accessibility to the young and the physically disabled. The NRM is seeking an interactive way for visitors to experience vintage railway engines without physically entering the vehicles. This interaction will enhance the experience of the less mobile and increase involvement for those visiting as part of large groups which cannot all enter the train car simultaneously. Building upon the previous research such as Active Prolonged Engagement (APE) and Life Enhancing Experiences (LEE), our team designed an exhibit that will appeal to these visitors and abide by conservation standards.

Our research will be part of the "biggest project that the museum has undertaken since the museum opened in 1975" (National Railway Museum, 2010). This project will aid in the museum's transition to more modern and exciting exhibits by replacing text panels with media that is more accessible and exciting to different ages and educational backgrounds. Our task was to share the thrill and majesty of British Rail with a younger generation.

This was an open-ended problem with a broad range of solutions. It involved researching, testing, and implementing an interactive exhibit focused on engagement and education. By learning how effective new media is in other museums and exhibits we discovered what works, what does not, and how to improve the systems in place. Interactive learning does not just take place in museums however, and so we evaluated the complete learning experience. Research on how new media is used in educational environments - from primary school through the university level – is still applicable. The project involved the synthesis of education, interactive media, and immersive technology to better the museum experience. We created a design for an "interactive engine experience" where the engine responds to the visitor.

Chapter 2 Literature Review

2.1 Introduction

Our project focused on an area the museum wishes to improve, accessibility. Numerous studies on the relevant topics of learning, accessibility, and interactive media currently exist. These key findings formed the backbone of our project. They have shaped our recommendations as to how an exhibit can improve this area. Overall, an exhibit needs to encourage learning for its target audiences, appeal to visitors, and be accessible. From this research we set the goals of accessibility, education, engagement, and fun for our final design suggestions.

Learning is at the heart of our project. Current theory suggests that interactivity is the most effective means of teaching. Museum studies in 'Active Prolonged Engagement' and 'Life Enhancing Experience' supports this theory. As technology becomes more omnipresent several teaching methods have been devised which can implement these new tools. Using this technology overcoming educational obstacles will be possible.

Along with potential educational barriers an exhibit presents, there are physical, audio, and visual ones too. There is a large segment of visitors unable to climb into an engine cab, see the controls, and experience a part of history. Can a visitor see the display? Can they hear the information? The answers to these questions can determine how effective an exhibit is at reaching its audience. Any designs we make must answer with a resounding yes.

New technologies make it possible to achieve even greater levels of interaction with once dormant exhibits. This is particularly noticeable in the area of user interface devices that currently use motion, touch, sound, and even brainwaves to bridge the gap between content and user. Technology can make exhibits come to life.

In preparation for the NRM+ renovation, the National Railway Museum has conducted numerous studies and audience research alongside independent research firms. The most prominent of these are "Life Enhancing Experience" as well as "Active Prolonged Engagement." We have taken these studies with their overall vision for the museum and applied them to the design of an actual exhibit with the goal of making it educational, accessible, engaging, and fun.

2.2 The Project Setting: NRM+ Renovation

The NRM+ renovation is a fundamental rethinking of the National Railway Museum's Great Hall. Beyond the physical renovation, a reworking of the building's structure, layout, and

look, NRM+ will change how visitors interact with and experience the exhibits. This undertaking will be the largest alteration to the National Railway Museum since its inception in 1975 (Bray, 2010).

To guide the renovation, the NRM+ team worked with both the in-house Audience Research and Advocacy department and an independent research organization (TWResearch) to identify the shortcomings of the museum as a whole and discover how the Great Hall can better serve visitors. Using this information, the NRM+ team identified their target audience, defined a new purpose, and determined ways to serve that audience. The team defined the target audience as families with children ages five to eleven and school groups of the same age. Families consist of near equal numbers of adults to children and can include the elderly and parents with buggies. School groups are larger (up to groups of thirty) and have many more children per adult.

Currently, the museum caters to steam engine enthusiasts. This demographic is primarily middle-age males. The new target audience is very different from the enthusiasts; they are not visiting with much (or any) prior knowledge of railways, cars, or engines. They visit as part of groups with varying ages, interests, and levels of mobility. In order to meet the needs of the new target audience, the museum must change the exhibits in two fundamental ways; present the engine in a manner that engages people of varying interests, and make them more accessible to the young, old, and large groups. NRM+ will educate visitors on the past, present, and future of both national and international rail travel. The presentation of the collection will cover both the technological aspect as well as the social context of railways in Britain and around the world.

2.3 Teaching Interactively: Improvements To The Learning Environment

The National Railway Museum's mission is to communicate railway history to the visitors. To accomplish this, we define and identity a learning environment suitable for a museum application. People of all backgrounds, interests, and learning styles visit the NRM. As designers, we need to create an environment that appeals to our target audience.

There are two concepts that will influence the visitor's educational experience at a museum: Active Prolonged Engagement (APE) and Life Enhancing Experiences (LEE). These concepts, developed for museums, describe best practice for interactive education and visitor engagement.

2.3.1 Active Prolonged Engagement

The APE approach to creating a successful learning environment originates from research conducted at the Exploratorium, a museum located in San Francisco, USA. The study, and exhibition of the same name, divides visitor experiences into four categories: exploration, investigation, observation, and construction (Humphrey & Gutwill, 2005, p.24). Using these four techniques, visitors stay longer at an exhibit and learn on their own.

Exploration is the open ended, unscripted travel through an exhibit's material. An exhibit which allows visitors to explore is one that allows visitors to decide what information is presented and at what speed. This is important because it makes the exhibit more personal by personalizing the experience- the experience is unscripted and unique.

Investigation in a museum exhibit is the act of allowing the visitors to answer questions for themselves. An exhibit that employs investigation has the visitor experiment or make educated guesses to find an answer. This experiential device, when implemented, changes the visitor experience from an authoritative, where the visitor receives information, to an experience where information is self-discovered.

The observation device is the visual representation of investigation and exploration. An exhibit that effectively utilizes this mechanism has a visual product or representation of information. Employing observation is not simply displaying results or data, but showing visitors what they, themselves have produced. Used with investigation, this concept brings concepts to tangible results and helps visitors relate information to everyday life.

Construction is the physical representation of investigation and exploration. Allowing the user to manipulate an element of the exhibit helps maintain interest and encourages investigation. Construction is naturally exploration and serves as a predecessor and complement to observation.

An exhibit from the Exploratorium, which embodies each of these four characteristics, is the "Make Your Pulley System" activity. In this activity, visitors can use a number of different pulleys and configure pulley-rope system to lift a small weighted object. They can then construct their own system, observe it functioning, investigate the effects of changing individual components, and explore new designs by configuration and even interlinking the creations of multiple visitors together.

APE has the goal of promoting "self-driven discovery," and, "a shift of the visitor's role from that of a recipient (of instructions) to that of a participant" (Humphrey & Gutwill, 2005,

p.3). This way, the visitor actively thinks with the information rather than passively listening to it.

2.3.2 Life Enhancing Experience

In addition to APE, our project is an application of the conclusions drawn from the Life-Enhancing Experience (LEE) study. LEE is a method created by NMSI to assess the quality of visitor experience. The criteria for a Life Enhancing Experience are connection, relevance interaction, and engagement.

Relevance, also called the "human connection," is the association between the information presented in the exhibit and the visitor's personal life. The social or personal connection helps visitors understand the purpose of the exhibit, and relate the information to themselves. By communicating relevance our exhibit will appeal to non-enthusiasts and help visitors understand the social significance of railways.

Interaction is the nature of exchange. An interactive exhibit must have two-way communication with the visitor. This interaction can be physical or non-physical as long as the visitor has the ability to manipulate a component of the exhibit. It is important for a visitor to interact with the exhibit to enable the learning process. Interaction makes a visitor connect with the exhibit and the material within.

Engagement means that the visitor is thinking with the information presented. In opposition to the classic text panel, visitors do not solely receive information but apply the information in an interactive way. Engaging exhibits, when combined with an interactive element, provide a fun learning experience.

Connection is the point of attraction for an individual. Visitors, when presented with an exhibit have a choice of whether to 'try' the experience or not. This criterion for LEE involves presenting the exhibit in a way that draws a visitor to the display or attraction. We need to design an exhibit that outwardly shows its features to capture the visitors' attention.

We used the criteria from LEE, in combination with APE, to design an exhibit which attracted, retained, and educated visitors. The next step in our research was to determine how we could use these concepts to address shortcomings of the current NRM.

2.4 NRM+ Specific Research

Prior to our arrival, the museum conducted several case studies in order to assess visitor behavior and satisfaction. The studies conducted on Rocket, the Royal Carriages, as well as a general study, "So what do you think?" revealed deficiencies in interactivity and access. These deficiencies are the purpose for our project.

2.4.1 Interactivity

The study, "So what do you think?" assessed the current visitor experience, the visitors' needs and wants, and the visitors' responses to the NRM+ draft plans. The museum completed research sessions with a wide range of NRM visitors such as railway enthusiasts, vacationers, York residents, etc (Bray, 2010).

This study found that interactivity was very limited. While the museum has a few interactive exhibitions such as "Mail by Rail," most of the exhibits are large, static objects accompanied by text panels. The study found that visitors wanted deeper experiences than sight and sound- they responded positively to the plans that involved multisensory showcases.

2.4.2 Context

While "So what do you think?" identified the lack of interactivity with the exhibits overall, the museum wanted to understand how visitors experience a particular exhibit in the museum. Rocket is an early engine located in the Great Hall. This study found that visitors struggled to engage with Rocket primarily due to a lack of quality interpretation and limited connection with its physical surrounding.

Through these studies, the museum learned that visitors wanted more than to just observe objects of railway history. It is necessary to explain and interpret both technical and social aspects of an object on display.

2.4.3 Visitor Engagement With Engines

The NRM conducted a study on one of a themed exhibition, the Royal Train exhibit. The objectives of this case study were:

- To understand how visitors engage with Royal Trains exhibit
- To identify what barriers exist to engagement
- To study how visitors engage with each other during their experience

- To understand why the Royal Trains is a 'highlight' for many visitors

There were several main findings from the study. Visitors liked the theme of the exhibition. It tied together objects separated in time, unlike any other section of the museum. The visitors felt however, that "…it could be taken further" (Bray, 2010). Also, there were serious barriers to experiencing the interior and the exhibition had a sense of adult focus, lifelessness, and obsolescence. These are all issues that the museum needs to resolve in order to continue attracting visitors.

2.5 Accessibility: Best practice And The Disability And Discrimination Act

By redeveloping the museum, the NRM+ team will bring a unique experience to first time and returning visitors. They realize the quality of the visitor's experience is directly dependent on how much of the exhibits they have access. As a result, designs must account for two major areas of disabilities, physical and audio/visual.

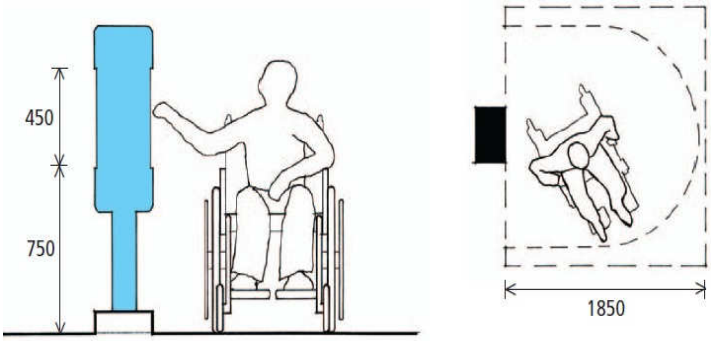


Figure 1 - Wheelchair Accessibility (All Experts, 2006)

Incorporating all the various needs of visitors allows the NRM+ team to appeal to a larger audience. Making sound exhibits audible will enable a larger group to listen to an exhibit at once. At the same time, a visual exhibit with high contrast will have a similar effect. An exhibit that involves user interaction must also fit the needs of a disabled wheelchair user. The average visitor, whose height in the UK is 175.0cm for men and 161.4cm for women (All Experts, 2006), is accounted for when designing tactile exhibits in accordance with the findings of the 2004 article 'Designing for Accessibility.' Figure 9, above, shows the height requirements in millimeters. The actual interactive touching portion must extend to no more than 450mm above

the 750mm point. The design must also take into account the floor space circa the display for wheelchairs, as shown in the right part of the figure above. This allows wheelchair users in an exhibit to enter or exit with an acceptable turning radius for them to use.

Any theatrical (auditory or visual) effects must be useable by all audiences. These guidelines set the NRM+ team on a path to design in direct compliance with the United Kingdom's Disability Discrimination Act of 1995 and 2005, which protects the right of the disabled by guaranteeing that public facilities provide an equal experience for all visitors (Virtual Tour Guide, 2006).

Making an exhibit both visually and aurally accessible will benefit the average museum goers as well. The same techniques used to accommodate the visually impaired, increasing text size, using high contrast colors, changing interface layouts, will also make exhibits clearer for other visitors as well. For designs accommodating the hearing impaired, adjusting the volume and provide other alternatives will only benefit the exhibit with added clarity. In both cases, increasing accessibility will only increase the simplicity and effectiveness of museums for all visitors.

Our project, a focus within the NRM+ project, deals with bringing an "Interactive cab Experience" to a visitor. Access is a key portion of this effort. Ignoring the problem will only alienate an intended audience. By designing an exhibit from the start with this factor in mind, avoiding this shortcoming is a much simpler task. Accessibility is only one area that the museum has targeted for overhaul. Audience research has identified several other areas as well such as the use and implementation of technology and media.

2.6 Technology And Media

Museums are a place of learning. They are very different from schools, as the presentation of material is not in the form of a textbook. Instead, museums consist of exhibits and scattered displays to convey the information in the form of text panels or display screens. This section discusses what new forms of media exist, and how we can use them in a museum setting.

Visiting a museum can emphasize prior knowledge and introduce others to a brand new idea or concept. Hands on learning can help better the understanding of a concept to visitors on a personal level. An example of this concept is looking at a 4-inch picture of a T-Rex in a textbook. Given dimensions of how each inch correlates to a certain length in reality, one can

have an idea of vast difference in size between himself and a full-size dinosaur. However, when you stand in front of the remains of the dinosaur, only then can one truly appreciate the difference (Survey, 2010).

Christopher Nash, the author of "Interactive media in museums" states, "In the beginning there was a radio." The radio, a device used for the simple operation of communication, was the apex of technology in the early 1900s. Since the time of the radio, education has used new forms of media and technology. Making items such as the radio for commercial use rather than only than for military purposes, enabled a broader range of technologies to emerge such as televisions, monitors, and so forth (Nash, 1992). Implementation of such technologies includes televisions, LCDs, and touch screens. Using these technologies to develop museum exhibits consisting solely of new types of media will bring a new age of museum exhibits. New technologies have the ability of replacing the text panels, and if done correctly, by introducing another level of immersion by promoting interaction with the user. The following section further discusses interactive technology.

When implementing technology, one must be wary of designing its user-interface. Many consider the museum setting a 'scripted' form of self learning. This means that the information presented, at a kiosk for example, in a museum is accessible in a predefined order or whatever order the user chooses. A kiosk should then avoid being linear with bland text or simply existing as a digital version of a text panel. This takes away from the advantages brought about by the various forms of media or as Isaac dubbed 'media aesthetics'. Isaac further explains that the use of monitors as an easy terminal bringing vast amounts of data to the user and could create a completely new learning experience. Understanding that various components need to come together smoothly in order to be effective is critical. Isaac explains that standalone, various components "creates a self-contained captivating aural and visual environment" (Isaac, 2008). Dumping the various components together created an "unrelated commotion" which is comparable to a marketplace. This takes away from the environment the museum should be creating (Isaac, 2008). A museum must organize its content so that topics flow well from one area to another. If a computer terminal available to visitors can effectively describe various parts of the exhibit with good organization it will yield desirable results such as increased amounts of visitors.

Within a classroom, not as many opportunities for teachers to interact with students exist (Siau, 2006). Essentially, implementing a curriculum consisting solely of interactive based teaching would be ideal, but is inefficient to spend the limited class time with the instructor getting responses from a single individual at a time. While it may be plausible in a classroom with few students, it would not be for classrooms with more students (Siau, 2006). A museum is an ideal location for interactive learning because it presents knowledge in a very open manner with technology complementing displays and exhibits. Interactive technology goes hand in hand with this teaching method. When used correctly, this type of technology can enhance and augment the message conveyed, ensuring that it is delivered. Properly implementing these techniques in conjunction with use of new media in a museum setting will encourage interaction as never seen before.

Involving technology in our designs made the exhibits more interesting for visitors to use. We used interactive technology in our designs in order to get the visitor more involved with the exhibit. In the next section we discuss the history of interactive technology and how we used it to design our exhibit.

2.6.1 Interactive Technology

From written word, to picture, to cathode ray tubes, the means of displaying a message has changed over the years. The National Railway Museum needs to update its attractions from that of simple text panels. Ultra slim displays using various technologies such as LCD, Plasma, and LED have become commonplace. Today, '3D televisions' are hitting the market. While hardly a revolutionary concept, this contemporary spin on what was once popular has evolved to the point where the iconic blue and red glasses are no longer necessary. Even though it may be new and exciting, time will tell if this amounts to an actual niche or just passing fad, as cost is an issue (Ohta, 2007). Meanwhile, holographic displays have also begun to appear in limited numbers. Intersecting beams of light rendered by projectors create a three-dimensional figure. You can see examples at conventions and business meetings demonstrating just what is possible with today's display technology. It is also possible to employ these technologies in such a manner that large numbers of people can interact with the display. Once again, cost is the defining issue (Agocs, 2006). Through new and exciting display technologies it is possible to excite visitors and foster a learning environment.

There are several ways to use physical interaction to enhance a visitor's experience and engage those previous. These methods make use of touch screen technologies as well as touch sensors on the artifacts themselves. Tactile control capabilities have developed far beyond that of your laptop's track pad. Touch screens add a whole new level of interactivity by allowing the user to touch and interact with what they are seeing. Touch screens are not relegated to small screens however. Recent years have shown development into screens with larger dimensions. Microsoft's "Surface" is a multi-touch display spanning an entire table (Microsoft, 2010).

There are numerous advantages of designing an exhibit based on this technology. The hands on nature allows for unprecedented interaction. It also allows for the control and visualization of concepts and areas that were once out of reach. "You come here and you can look, but you can't touch anything. In a way, we're letting people touch the objects now -- look at them, turn them around, find out more about them"(Crowell, 1997). When the physical object is available, one can use this technology to enhance visitor experience and facilitate learning. While having the actual physical piece of history in front of the visitors is ideal in many situations, it is not always the best solution. If the museum contains too many objects sprawled out in all directions sensory overload can occur (Griffiths, 2000). Technology such as touch screens and computers can alleviate this problem by conveying the same themes and stories in a small concise package.

Despite these many advantages, there are several drawbacks to relying heavily on technology. With a touch screen it is possible to convey a large volume of information. Increasing the size complexity of a display may detract from the original value of the artifact it describes. Price is another issue. The cost of such displays can range from several hundred to several thousand pounds (Protouch, 2010). While potentially cheaper than the artifacts they can replace, the installation and upkeep of such technologies can be costly. In addition, researchers debate at what point technology becomes a distraction which detracts from the message. This debate is not new. The experts of their day made the same argument in the early 1900's when museums began incorporating photographs to complement their exhibits (Griffiths, 2000). One cannot easily dismiss the question despite age. The museum must account for it with the introduction of each new exhibit.

Recently, games and technologies are in development centering on new methods of interaction. Motion capture, a technology with roots traced to films from the seventies, is the

latest form (Sturman, 1999). The first commercially successful console to incorporate this technology was the Nintendo Wii in late 2006. . Now, Sony Playstation 3 is following the lead by developing a similar technology that uses a camera to track a glowing ball mounted on a controller. Not one to be left behind, Microsoft has also entered into to the fray with Project Natal, a stereovision camera system which eliminates the need for a controller altogether by tracking the player's body as it moves and also including facial recognition technology (Porges, 2010). By incorporating one or more of these interactive technologies, it may be possible to make the National Railway Museum a much more engaging experience for its visitors.

What once started as several moving blocks on an oscilloscope, video gaming is now an industry worth over ten billion dollars that has become one of the most immersive forms of media to date. This strategy has the potential to attract large groups of visitors. What makes a game worthy of attention is now the subject of theory and formula. The game draws the player in using techniques such as varying challenge, controlled information release, and the dramatic and thematic elements borrowed from novels and films. Despite the importance of these attributes, "in the end, the real importance of good computer and video games is that they allow people to re-create themselves in new worlds and achieve recreation and deep learning at one and the same time" (Gee, 2003, p. 3). Learning, one of the main and often overlooked reasons behind games and their players is very real. The potential for players to learn from games has increased constantly over the years, as has the technology. If the catch, *what makes the game "fun,"* is strong enough, players will return and they will learn (Shaffer, 2004). In many regards, video games are the answer to the age-old question of how to share the knowledge and joy of learning to a younger generation. Using these technologies it is possible to create an unforgettable experience for the visitors of the National Railway Museum.

2.7 Summary

The National Railway Museum is dedicated to telling the history of railways in both Britain and around the world. In order to tell its story better, the museum wishes to update its displays with the latest in technique and technology. Over the last decade, numerous advances in displays and interactive media have become commonplace. These technologies allow for the instant capture and recognition of speech, motion, and facial features. At the same time, experimentation in new methods of teaching and creating learning environments are occurring.

Separately, these things help convey information; together they mean total immersion and more importantly, learning.

What we have learned in our review of the best practices of education, new media, and museum marketing, is that museums present an opportunity to bring both new and old education methods with new technology to create an interactive, immersive, and fun learning environment. New exhibits with these developments can bring more visitors and more revenue to a museum while improving retention of information.

From our visit to the Boston Museum of Science, we had a chance to see some of these theories and ideas in action while also gathering ideas on how to improve interaction and immersion. While some of the most popular exhibits we saw were interactive and immersive, we also learned the importance of a visually striking display. Some fenced off or glass encased exhibits drew crowds purely on their display. While our project specifically focuses on interactivity, we brought all of these ideas to National Railway Museum for our project.

Chapter 3 Methodology

3.1 Introduction

A main goal of this project was to create an equivalent museum experience for those unable to enter exhibit space physically. We proposed an exhibit design that would allow the less mobile and their parties to have an equivalent experience to those who can enter the cab at the National Railway Museum, York, United Kingdom. While we designed for the Duchess of Hamilton, an iconic steam engine of the Princess Coronation class, our design is applicable to the wide range of steam engines in the museum collection.

After completing our research, our first step was to consult with the staff to gain a better understanding of how the visitors interact with the employees, and what kind of questions they ask. We observed visitors at the Duchess of Hamilton to evaluate how visitors interact with it. We pulled important criteria from the research and the staff consultation. These criteria lead to the creation of a matrix to evaluate our ideas. The five important studies we took criteria from were: LEE, APE, accessibility, staff consultation, and Audience Research and Advocacy (see Literature Review, 2.3). We then used our matrix to narrow down ideas by eliminating those which did not meet all of the criteria. Finally, we measured if our exhibit idea met the criteria through prototype testing. This section will go over the steps we took to finalize our design ideas for our recommendations to NRM+.

3.2 Staff Consultation

Early on in our project we identified the need to consult with museum staff. The employees of the museum know the inner workings of its routine and day to day operations. The staff has worked with visitors for years and has a good understanding of what visitors want to know, what visitors ask, and what visitors do. In this section we describe how we interacted with the employees.

3.2.1 Individual Interviews With Staff

One-on-one interviews with key staff members gave us more detailed information on how the museum runs and how the staff interacts with the visitors. Each staff member comes in contact with different visitors and experiences different responses because of their gender and

age. We held interviews with a few employees of different ages and genders to gain a better understanding of how visitors interact with the exhibits and what kind of questions they ask.

All of our interviews took place with members of the explainer team. Explainers are the museum's staff that run special presentations, answer visitors' questions, and work directly on the museum floor. Every explainer has in depth knowledge regarding how engines work and the history behind them. This allows them to interact with all visitors, from children to the elderly.

We interviewed two explainers, Lizzie and Lucy, to get more detailed information on how they interact with the visitors (Appendix A: Interview With Lizzie And Lucy). They explained the difficulties of working with large diverse groups, balancing the needs and wants of each member. The two explainers suggested several ideas they would like to see in an exhibit. Talking with them gave us an even better understanding of what the visitors want to know and how they interact with the staff.

We got a chance to go into the cab of the Mallard with an explainer, Ian. He described the daily struggles of railway work during the time when stem engines were in operation in Brittan. He also explained how it is inside the cab of a stem engine while it is moving down the track (Appendix B: Interview With Ian). The work was hard and dangerous. He gave us a background on the rail industry, a description of what it was like working on it, and a further explanation of the relationship between the driver and the fireman.

Meeting with Ian reinforced the idea of using theatrical effects to immerse the visitor in a cab experience. Earlier in our research we highlighted the need for an exhibit to link the engines with the men and women behind them. Ian reaffirmed this concept.

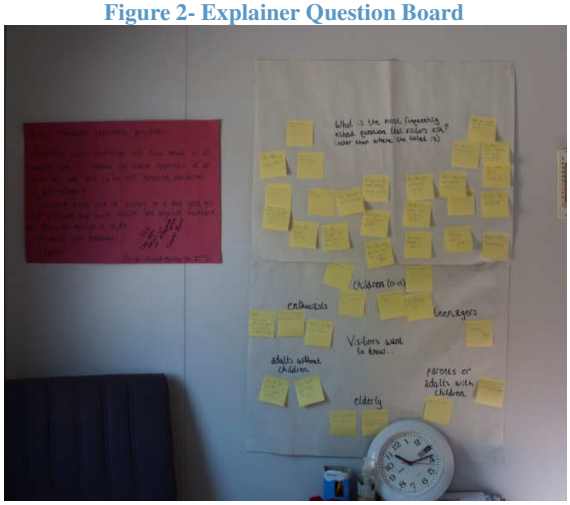
3.2.2 Consultation With Explainers

Since the explainers interact with visitors on a daily basis, hearing both positive and negative feedback, we created a set of general questions for them to answer. As a supplement to our individual interviews and to receive a range of opinions we posted questions in the explainer break room. We stratified the questions by demographic (children 0-11, teenagers, parents or adults with children, elderly, adults without children, enthusiasts) and designed them gather different ideas and suggestions. After a week, we collected and analyzed their answers (Appendix C: Consultation With Explainers). The questions that we asked them were:

- What are the frequently asked questions?
- What do the different age groups want to know about?

- What are the barriers for the disabled engaging with the vehicles?
- Can you think of any uses for technology to better enhance visitor experience?

Figure 2- Explainer Question Board



The responses from the explainers showed that visitors, especially children, wanted to know how to drive steam engines. While the explainers said that they are able to explain driving operation to children, the cabs, the area in which the fireman and driver operate the engine, are too small to accommodate more than four to five people. The explainers responded that for large groups, they would gather outside the engine and explain driving conceptually. In subsequent responses, it was clear that this technique was not effective and that explainers often changed the subject to more tangible topics relating to steam engine operation.

The explainer responses directly influenced the design of our prototypes. The "You're the Driver" design was an attempt to answer the question of how one operates a steam engine. We designed "I Spy" as a tangible exhibit which focused on the individual pieces of a steam engine rather than the engine as a whole.

3.3 Observation

The next step in our process of designing an exhibit was to observe visitors. Observing visitors is a good way to gain our own understanding of how they interact with the engines, especially the Duchess. To guide our research, we constructed an observation sheet highlighting key topics we wished to observe (Appendix D: Observation Sheet). We identified what visitors looked at, what they touched, and what they talked about. Integrating current visitor behavior with our research helped us formulate our design ideas (Appendix E: Observation Study). After observing the visitors, we created a matrix to evaluate our ideas.

3.4 Matrix

To narrow down the number of design ideas we used the criteria listed in Table 1 – Criteria for exhibit that our exhibit had to meet; this was our next step. Before presenting our exhibit designs to the NRM+ project development team, we had to assess their effectiveness based on the standards set by NRM+, Audience Research, LEE, and APE. Based on the findings of these groups and studies, we created a list of concepts, pertinent objectives, that need to be met. The concepts can be found in a matrix (Appendix F: Criteria Matrix) summarizing the criteria on which we evaluated our designs. The matrix consisted of a brief description of each objective, each concept, and the evaluation of our designs. The goal was to allow for easier comparison of design ideas qualitatively.

Table 1 – Criteria for exhibit

Concept	Testing Criteria
Education	Learning takes place without the visitor feeling like he/she is being taught.
Memorable	The visitor leaves the exhibit having learned something educational.
Inspiring	Provides the visitor with an experience that surprised them.
Interaction	Exhibit attracts people to it. The exhibit encourages social and cross generational interaction.
Engagement	Visitors will ask questions of the exhibit and look for answers to them.
Authenticity	Visitor will feel that the exhibit provides an experience of an authentic railway experience.
Open Ended	Allowing open ended exploration with "gentle guidance" - not a scripted experience.
Self Driven	Minimizing instruction and explanation- encouraging visitor-initiated observation, speculation, play and construction.
Participation	Visitor uses information from the exhibit during interaction.
Connection To People	The exhibit creates a connection from the visitor to a family member, memory, or other social topic.
Physical	Physical accessibility for disabled individuals means better accessibility for school groups and families.
Visual	Best practice sensory accessibility allows more people to experience the exhibit.
Environment	Create a multi-sensory, immersive experience.

We used the criteria in the table to evaluate our design ideas and to eliminate the ideas that did not meet all of the criteria. Using the matrix we found two exhibit ideas that could meet all of the criteria and warranted further development. We used prototype testing as a way to measure how successful we were at reaching our goals.

3.5 Prototype Testing

To evaluate our design ideas, we constructed prototypes and conducted trials with museum visitors. We asked visitors to use each of our prototype designs and then asked them several questions about their experience. By either observing or interviewing the visitors, we

measured the thirteen criteria identified in our matrix. After the testing, we assessed the responses, and proposed changes before presenting them to the NRM+ team.

3.5.1 Observation Testing

The concepts that we measured through observation were interaction, engagement, open ended, self driven, participation, connection to people, physical and visual. This table lists the concepts and how we measured them.

Table 2 - Observation Measurements

Concept	Measurement
Interaction	Look for two-way communication with the prototype
Engagement	Determine if the visitors asks questions and look for answers
Open-ended	Determine if the visitor explore the exhibit without outside help
Self-driven	Without giving the visitor systematic directions, see if the visitor can progress
Participation	Visitor uses information from the exhibit
Connection to people	Look for conversations or statements regarding memories or personal stories
Physical	See if the visitor can physically access the exhibit
Visual	See if the visitor can understand the directions and interface of the exhibit

We used these measurements to verify if our prototype met our goals. Our observation sheet included guidelines for observing these concepts. (Appendix G: Prototype Testing Observation Sheet).

3.5.2 Interview Investigation

The concepts we measured through interviewing visitors were educational, memorable, inspiring, authentic, and environmental. This table lists each concept and how we determined if our ideas met the criteria.

Table 3 - Interview Measurments

Concept	Measurement
Educational	Ask if they found anything new during the experience
Memorable	Ask if there was anything they took from the exhibit
Inspiring	Ask if anything surprised them while using the exhibit
Authentic	Ask if the visitor if they felt it provided a realistic train experience
Environmental	Ask if they thought that the lights and sounds added to the overall experience

We used these measurements to verify if our prototype met the visitors' needs. Our question sheet lists these measurements in the form of direct questions. (Appendix H: Prototype Testing Questions).

3.6 Summary

The goal of this project was to design an exhibit that would provide an equivalent experience for all visitors. This design must be applicable to all engines housed at the National Railway Museum. We conducted research into accessibility, education, and museum experiences. Our group worked towards understanding these best practices in order to accomplish our goal for the museum.

Chapter 4 Findings

4.1 Introduction

This Findings section discusses the final two designs, “I Spy” and “You’re the Driver,” in depth. In our methodology section we discussed how earlier in our project we had four design ideas and how we distilled the ideas to two unique exhibit designs. This section discusses what the final exhibits were and then explains how they meet the goals of the criteria mentioned in the studies (Appendix F: Criteria Matrix). The feasibility of implementing these two designs depends on how well they meet the various criteria posed by the various studies such as APE and LEE.

4.2 Observation Results

From our observation study, there were several prevalent behaviors of visitors. The first observation was that the Duchess of Hamilton exhibit was not interactive. This caused many of the subjects of our observation to spend about the time it takes to walk past a train at the exhibit. One of the goals of this project, set by APE, was to keep a group of visitors at the Duchess for a longer time period than current exhibit has.

While many visitors did not spend much time at the exhibit, we were able to make quality observations from those who did. The Duchess is possibly the most distinct locomotive in the Great Hall. The streamline casing gives it an overwhelmingly unique look and sets it apart from any other locomotive that we have seen. The bold coloring scheme it has also attracts a wide variety of visitors that simply want to take pictures of it or of their family with it. This means that any design idea we submit to the NRM+ team must not inconvenience visitors, who may feel it ruins their pictures.

Another important observation was visitors’ desire to go inside of the cab. Like many other exhibits, there is no cab access unless an explainer is present as there have been security and conservation issues in the past. For those who stay, there is not much to do other than read the text panel and watch a short video. Our exhibit design gives visitors a chance to do more than just read and observe. Since cab access is restricted, it gives families a fun and interactive activity to do while there are no explainers to aid their visit.

4.3 "I Spy"

4.3.1 Description

The popular I Spy series of books and games, where the reader must find objects based on given clues, inspired our first exhibit design. This design, named "I Spy," consisted of two parts. The first was clues to parts of the locomotive. In the prototype, we gave visitors clues in the form of text descriptions and silhouettes. Based on the clues, visitors must go up to engine and find the answer on the exterior. Upon touching the object, well within reach of children and physically disabled, the engine will spring to life by use of dynamic lighting, sounds, and other theatrical effects. A historical background and significance of the particular object served as a follow up to the success.

4.3.2 Prototype Testing

Preliminary questions for "I Spy" allowed us to gain an initial understanding of what both the parents and children thought of the Duchess of Hamilton. Every response to the question "What are your initial thoughts of the Duchess?" consists of praising its look such as its streamlined body. Many answered the follow up question "What, if anything interests you about this engine?" in a relating fashion by commenting on its magnificence. From this we understood that there was not as much appreciation for the smaller parts that make up the whole engine as much the whole engine made up of the small parts.

The observation period consisted of the visitors playing "I Spy." We tested this prototype on parents visiting with children 5-11. Parents received a sheet of paper with what to spy for, and some information relating to that object. The directions were for them to read out a description of the component to their children and wait for the child to find the object. After the children had the chance to touch or point at the component, parents had the choice to read the relating information or go on to the next component.

After playing the game, we interviewed the parents and children again to gain an understanding about their experience. We structured this set of questions as a detailed, probing version of the preliminary questions, with the intention of measuring how well "I Spy" met the criteria.

4.3.2.1 Education

"I Spy" meets this criterion of education in two ways. First, learning takes place when the visitor finds the component of interest through the description. By giving clues in multiple ways there is opportunity to associate the component with its use. During the observation session of prototype testing, a father explained to his daughter what buffers were and their uses after she found the object from the silhouette even though she didn't understand the textual clues. The girl was able to learn what buffers were, how they look, and what their use is. Second, learning takes place after the visitor has found the correct answer through audio feedback. While we were not able to test this fully in our prototype, we tested it, in part, by have the visitor read information after he had found the correct answer. We found that this method was not effective because visitors lost interest correctly answering the question and quickly moved to the next clue.

4.3.2.2 Memorable

"I Spy" is memorable because it gives visitors useful information along with physical descriptions to find components. After finding the component described, the exhibit gives the visitor some information. The information provided in "I Spy" gave visitors a greater appreciation for steam engines. During one interview, a visitor stated "I think this is about focusing on bits of the train." She went on to say that she had never noticed the individual pieces before. While there is insufficient data to determine whether our prototype was memorable, breaking down preconceived notions is one way to make an exhibit memorable.

4.3.2.3 Inspiring

By pointing out specific parts of the engine we hope that this design will encourage players to learn more about engines and their workings. There was no evidence from our prototype testing that visitors sought out more information about the information afterwards; however, we were not able to conduct follow-up interviews.

4.3.2.4 Interaction

The "I Spy" design is naturally interactive. From our prototype testing, we found that adults led the game with their children and a two way conversation. Parents helped their children when needed and the children sought help from the parents when unsure. "I Spy" was naturally suited for families and groups with children.

4.3.2.5 Engagement

Families come together to find answers for “I Spy.” They are engaged in touching or pointing at components. Children enjoy the encouragement from parents for finding the correct answer. Parents enjoy their children playing a game they enjoy and seeing their faces light up upon finding the correct answer.

4.3.2.6 Authenticity

“I Spy” meets this criterion of authenticity by giving users the freedom to explore and touch the actual engine. The “I Spy” design does not separate the visitor from the engine in any way. It encourages the visitors to get close and physically touch the engine; at the same time, encouraging visitors to take a closer look.

4.3.2.7 Open-Ended

There is no incorrect way to arrive at an answer for “I Spy.” This means visitors can interact freely with the exhibit. The questions are not linear and do not need to be answered in a certain order.

4.3.2.8 Self Driven

In order for an exhibit to be self driven a visitor must want to continue on to the next hint or clue of their own accord. By taking advantage of the games familiarity and including a reward system based on positive reinforcement, visitors want to continue playing. Based on our prototype testing, visitors wanted to continue playing because they were having fun.

4.3.2.9 Participation

“I Spy” allows for more than a single individual to play. The game encourages parents and children to work together. The prototype fostered the same cooperation between individuals. Our prototype testing showed that even with up to four children simultaneously looking for the answer, the participants continued to work together towards a common goal.

4.3.2.10 Connection to People

Our prototype testing showed that by allowing visitors to set their own pace, parents and children had time to stop and share stories during the game. For example, after finding the nameplate of the Duchess of Hamilton, a woman told her son “this train was built the same year

granddad was born!" She was able to make a connection to an otherwise seemingly inconsequential number on the side of the engine.

4.3.2.11 Physical

Our "I Spy" design only requires that the player have access to the side of the engine. The museum can adapt the game for both wheel height and platform height exhibits. The only requirement is that the objects must be reachable. The Disability Discrimination Act defines reachable and encompasses the requirements for both children and the physically disabled.

4.3.2.12 Visual

Designing for the visually impaired allows for more people to experience the exhibit. Any text displays used will have high contrast to allow easier reading. This will not only allow those with vision problems but also those who are further away to read the information. By designing for those who have a visual impairment, we are making sure the information is better accessible.

4.3.2.13 Environment

"I Spy" does not convey all aspects of the engine. For example, the cabs and higher objects would still remain inaccessible. However, it invites visitors to do something more than take pictures of an engine. The exhibit engages visitors with games that may contain sounds, visuals, and other theatrical effects.

4.4 "You're the driver"

4.4.1 Description

This exhibit design is a game where the visitor has a chance to get a basic understanding of how to drive a steam locomotive without the intricacies and complications induced by a simulator. The goals of this concept were experimentation and open-ended exploration. The game presents a player with a stationary engine, simplified control set, and minimal directions. It is up to the player to experiment with the various knobs and levers. The engine will show the effects of each decision. The game encourages visitors to get the engine to its destination. There is the possibility of introducing the aspect of competition through multiple control sets driving multiple engines on parallel tracks in a race to the finish line. This game uses a variety of effects

such as heat, steam, lights, and sounds to heighten the engine experience. This flexibility allows for the compliance with multiple criteria.

4.4.2 Design

While we designed to meet each criterion, unfortunately, we were unable test these hypotheses due to time constraints and other factors. The following section describes how we envisioned our design would meet each criterion.

4.4.2.1 Education

"You're the Driver" meets the criterion of education by teaching visitors the basic operation of a steam engine. This occurs through experimentation and investigation. By allowing users to operate the controls physically and experience a response there is potential for learning to occur.

4.4.2.2 Memorable

"You're the Driver" is memorable by giving users a basic understanding of how to operate a steam engine. Visitors who have played as the driver can understand the complexities of driving by controlling all of the levers and knobs. This multisensory experience, possibly the first driving experience of any powered vehicle, should remain in the visitor's memory for a long time.

4.4.2.3 Inspiring

Users of "You're the driver" will have a greater appreciation for the skill to operate a steam engine. We hope that the appreciation and experience from driving the engine will provoke visitors to pursue more information about steam engines and the railway.

4.4.2.4 Interaction

"You're the driver" invites visitors to compete against each other in driving an engine. This exhibit is a game which is naturally interactive. Users operate the controls, see the response on the screen, and experience the engine running through multisensory effects.

4.4.2.5 Engagement

Similar to "I Spy," the information provided in "You're the Driver" is brief and allows for experimentation. Visitors may or may not read the instructions in their entirety, but the controls are not hard to master after a short period of trial and error.

4.4.2.6 Authenticity

The game "You're the driver" includes a simplified, but working, control set. Using the controls, one can operate the engine and experience the response. While this response is realistic it is not authentic.

4.4.2.7 Open-Ended

This game is open-ended because the events are not scripted or sequenced; the user determines what happens in the game. Because the game only has one goal, to reach the end of the track, exploration is limited. However, the experimentation aspect allows for an open-ended experience.

4.4.2.8 Self Driven

"You're the driver" provides a brief explanation at the beginning of how to drive the engine. It is up to the operator to experiment with the controls and teach themselves how to drive the engine. We envision the game to have a small learning curve, and we hope that the competitive aspect entice visitors to practice.

4.4.2.9 Participation

If the user chooses to read through the initial instructions, they will have a better idea of how the controls work for "You're the driver" the first time they try the game. If the visitor plays the game a couple of times, he/she can master the controls.

4.4.2.10 Connection to People

Stories of social and historical significance will appear on the screen. While we don't expect the operator to read these while playing, it is our hope that the audience will find these stories interesting.

4.4.2.11 Physical

The controls of “You’re the driver” will be in a location accessible to someone in a wheelchair. Unlike “I Spy,” it will not be accessible to a large amount of people at once; rather it will only be accessible to as many people as there are control sets. While the limited number of controls will force some visitors to spectate, they still get a chance to see the display screen, which shows the progress of the driver.

4.4.2.12 Visual

The visual display of “You’re the driver” is well above the visitors’ normal line of vision so that all spectators may observe the game as it progresses. The attention of visitors will be at a higher location than devices used for the “I Spy” game because it is not responsive in the same way and doing so allows a large audience to look on as the game progresses.

4.4.2.13 Environment

The control set of “You’re the Driver” is a simplified mockup of the actual controls found inside of a real cab. This exhibit can contain various theatrical elements such as sound, heat, smoke, and steam.

4.5 Conclusion

Overall we felt that our designs met all of the criteria. We found “I Spy” did not meet the educational aspect as well as we expected. The information presented that was given after the visitor correctly answered the question felt more like an afterthought and visitors did not pay attention to the information. We recommend that future developers of this idea create clues that include educational information in the prompt.

Chapter 5 Conclusion

The NRM recently obtained funds to undergo a complete renovation of the Great Hall. The most important changes are those that will provide more accessibility to children, families, and disabled. The museum is looking for an interactive way for visitors to experience an authentic cab experience without physically entering the vehicles. The exhibit will give the less mobile a better experience and increase involvement for visitors in large groups. Building upon the previous research such as APE and LEE, our team designed two exhibits that will appeal to these visitors. This project will help the museum's transition to become more modern and exciting by replacing text panels with media that are more accessible to different ages and educational backgrounds. Our goal is to share the experience and technology of train engines with a younger generation.

After completing research, observing visitors, designing prototypes, and testing those prototypes we recommended two exhibit ideas to the NRM+ project team. These two prototypes will help the museum with the transition as we designed them from start to finish incorporating the latest research and NRM+ goals. They are the culmination of our seven-week project. As the museum metamorphosis begins to crystallize, the same factors that have shaped our project will drive their designs to improve learning and education, carrying railway history into the future.

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Appendix A: Interview With Lizzie And Lucy

- Visitors often react to cab as “omg this is complex” - explainers show how to drive a train
    - Everyone wants to know how to drive a train
- Sensory experience – visitors don't get the idea of hot, cold, camped, dirty, loud
- Middle aged couple
    - Man → nrm
    - Woman → shopping
- Female audience
    - “this is what you would do as a firemen... then pull lever”
        - Shows both the how/what as well as a more personal experience
        - Not just personal/social aspect
- When cab isn't enterable – point and explain
    - Or go to other cab
- (steam “great western railway” in Swindon has a legit simulator)
- How a steam engine works and how to drive one
    - Right now these are separate – would be nice if they could be linked together
- Allow adults to lead children
    - Simple enough for the parents to understand and then explain
    - (teachers to explain and/or quiz children – from 20 May observation study)
- Atmosphere – enclosed space
    - good with lots of people – can feel the claustrophobia and heat
    - fireman and driver – closeness
        - fireman would draw a line down the middle of the cab if he didn't like the fireman
- Bad questions
    - statements of facts – knowitalls
    - injectors explanation – complex tech
        - some people want to know
        - others don't
- Life of the crew men – day in the life
    - jobs
    - life at home
    - hours a day
    - what they did at work
    - hierarchy of workers and management
    - pay
    - how got to work
- What explainers want to talk about
    - Bits and Bolts – what makes different engines different
        - little details
        - wyvern the symbol of xyz
        - something of British history
        - technical differences → 60% of people don’t care
        - wrapping hands in cloth to keep from burning

        - wearing gloves was looked down upon
- 'think about how I would tell my mom how this works'
- What we should/shouldn't do
    - Keep away from a simulator idea
    - complex but not too complex
        - 12 y/o learning level
    - personal / relaxed
    - buttons – speak to you not at you
    - very short + broken up displays
    - height difference of cab and ground
    - sensory experience – heat, dust, noise, space
    - no models – people like the real thing and the real size
    - sensory doesn't need
- Some other cool ideas
    - Yorvic: “dig” - little person on the bookshelf
    - displayed cab with person + personal stories

Appendix B: Interview With Ian

- Sound – specific whistle note
- Heat – wooden floor
    - 1400 C, cremation temperature
- Dust – driver had to wash down floor with steam hose
- Water level – used refraction to get accurate reading
- Lighting in cab – cab was dark, dim, dusty
- Visibility – at 80mph at night you cant see
    - "Rocking and rolling" down the track
    - Can't see environment at night
- Quantity of fuel
    - 5000gal/18 mi worth of water
    - 1 ton of coal/ hr
    - Unit conversion on the railway
    - Actual piece of coal – children don't know what coal is
- Difference driving trains today vs. steam trains
    - Requirements to be a driver
        - Eyesight, color acuity
    - Things children don't know
        - What is coal (see above)
        - Seatbelts/ safety
- Smell – hard to reproduce
    - Steam
    - Coal
    - Lube oil
        - Rated in temperature not viscosity
        - At high temperatures the oil will "crack" aka break down
        - distinctive smell
        - Difference between old oil (animal fats) and new oil (ground oil)
- Danger
    - Hot steam
    - Heat from fire
        - Tunnels – blow-back
    - Air quality
        - Problems with working around burning coal?
- Hard work
    - Shoveling coal
    - What the driver had to know/ consider while driving
    - Structure of railway business
        - Age 15 – retirements (age?)
            - Started by cleaning the hot engines (or even earlier- job?)
        - Gave watch when retired – irony
    - Life back home of railway workers and what the family structure was
        - Legacy? Sons follow fathers through the railway system

Appendix C: Consultation With Explainers

What is the most frequently asked question that visitors ask? (other than where the toilet is)

- Where is the flying Scotsman?
- Are there any railway posters?
- Where are the Royal carriages?
- What time do you close?
- Where does the money come from to pay for the museum?
- Where is Thomas?
- When did Mallard last run?
- Is the bullet the fastest train in the world?
- How many work here? (in w/shop)
- Can you fix the model railway? Nothing is moving
- Have you any railway photos?
- How long have you been here? (Railway Museum in York)
- Are there any paintings of railway engines?
- Did this (station hall) used to be a station?
- How many Mallards are there?
- Do you want to be a train driver?
- What did that tannoy just say?
- Is this what is happening now? (screens giving departures on York Station)
- How long have you worked here?
- Is there still a Royal Train?
- Where is the café?
- Is this the real Rocket?
- Are you paid or volunteer?
- What is the Search Engine?
- Where is Mallard?
- Where is the Restaurant?

Visitors want to know…

- ***Children (0-11)***
    - Where does the driver sit?
    - Which trains look like those from Thomas & Friends?
    - Which one makes it go?
    - Is Thomas here?
    - Where the whistle is.
- ***Teenagers***

    - Generally how it works (only select few).
- ***Parents or adults with children***
    - Where is the toilet?
    - Where the coal goes, how does it work basically, where's the driver's seat?
- ***Elderly***
    - When was it built, when it last ran.
    - Where abouts the engine used to run? (in case they've been pulled behind it before)
- ***Adults without children***
    - Why don't you charge? (to come in)
    - How do you keep the bronze/copper so clean?
- ***Enthusiasts***
    - Which loco's are still running? ie in working order (in the museum)
    - What are the peculiarities of the engine? ie design features that are unusual
    - Where built/by whom?

Can you think of any way that we could use technology and media to enhance visitor experience both on and off cabs?

- Recreate the sound + smell of a steam engine! (ie on the footplate)
- Diesel equivalent of Ellerman lines
- Use of animation
- No emphasis on what you CAN see from floor level ie shapes/sizes, methods in which engine fitted together.
- Have an electronic visual display saying what talks are on i.e. times + locations. Would help avoid 'what did tannoy just say?'
- Use of sand/lights
- Improve the audio guide, it is terrible and VERY out of date.
- Use compressed air for example, to recreate the sound of a steam locomotives whistle when you pull it, especially with a locomotive on the turntable.
- Update the current Sound Guides with perhaps and IPod-type device, to maybe include images and short bits of film, to give some of the stories behind the objects in the collection, including the locomotives.
- Use of rain Simulators using actual cabs (for example, the Duke of Gloucester cab currently in the Learning Platform), the HST (High Speed Train) cab and Pendolino cab, both of which I believe, may be currently in the Concrete Works. Using commercially available Train Simulator programmes the controls in the cabs could be rigged up to work. It may perhaps also be possible to create the sounds and maybe smells of the locomotives? They could perhaps be set up in such a way where they would not have to be manned as the Simulator currently in the Museum is. (The kind of Train Simulators

which the NRM Director Steve Davies spoke about, on his and Helen Ashby's, recent visit to the Railway Museum in Tokyo).

What are the barriers to disabled visitors engaging with vehicles at the NRM?

- Useless sound guide!
- Lack of training/understanding of autism/learning disability
- Many! There is no disabled (wheelchair) access to most carriages and cabs.
- Access to all areas of museum + objects mobility/sight.
- Time- for learning disability to meaningfully access cabs.
- Signs and information boards are not always placed in positions which can be read easily by people with disabilities, for example those in wheelchairs.
- Not all visitors can gain access to the cabs as they are not able to climb up the steps to go inside.
- For visitors with visual impairments there is no information about the locomotives available in Braille or in larger print.

Appendix D: Observation Sheet

WPI NRM Observations

Exhibit: Duchess of Hamilton

Observer: _____ Date: _____ Target: _____ (School/Family/NA) (M/F) Age: ___

Things to look for:	*Observations:*
-What is their mood when they arrive? -Do they notice the text panel? -Do they read the text panel? -Do they point to anything in the cab? -How engaged are the other members of the group? (if applicable) -What conversation is occurring(between group/ "leader")? -Do they touch the train...where? -Where do they look for answers? -Why do they leave? -What is their mood when they leave? -How long do they stay? -How much time do they spend looking into the cab?	

Appendix E: Observation Study

Observation Study: Duchess of Hamilton

Summary

OBSERVERS
Mohammed Alhassan
Andrew Brown
Brian Franklin
Kyle Warren

Introduction

This document is a summary of the observation studies done on Saturday June 12th, 2010 between the hours of 1:00 pm and 5:00 pm at the National Railway Museum. The target of observation was the Duchess of Hamilton and the portions of the "Streamlined" exhibit relating to it.

Observations

- Visitors spent anywhere from a few seconds to ten minutes at the Duchess. The average visitor spent roughly two minutes walking around the engine exterior and briefly glancing at the text and video displays.
- Size was the main feature that visitors were impressed with. The Duchess's wheels in particular were the topic of many conversations.

"WOAH!! Those are HUGE" ~10 year old girl commenting on the wheels

- Older visitors (60+) tended to stay longer at the Duchess reading all of the text panels and watching the video of its record breaking run.
- Most visitors watched at least some of the video. Those who stayed longer than a minute at the Duchess engine usually watched a good portion of the video.
- On one side of the engine there was no information. Visitors would often circle the train to find the information before walking away shortly after.
- Most visitors touched the locomotive at some point. This was especially true with younger visitors who would reach up and grab portions of the engine, particularly the buffers, wheels, and streamlined panels.

Appendix F: Criteria Matrix

Evidence for Criteria					Topic	Testing Criteria	Method for Measuring	You're the driver
	APE	LEE			Education	learning takes place without the visitor feeling like he/she is being taught.	Ask if they found out anything new during the experience.	learning will take place during the instructional screen(s) before the user drives the train. It will also take place during the driving itself as the user figures out how to use the controls and how each one affects the train's movement
	APE	LEE			Memorable	The visitor leaves the exhibit having learned something educational	Ask if there was anything they took from the exhibit	The user will take away a basic understanding of how to operate a steam engine.
		LEE			Inspiring	Provides the visitor with an experience that surprised them.	Ask if they found anything surprising during the experience	The users may have a greater appreciation for the skill required to operate a steam engine and may want to persue the hobby.
	APE	LEE			Interaction	Exhibit attracts people to it. The exhibit encourages social and cross generational interaction.	Look for two-way communication with the prototype	We hope that the exhibit, by answering the question 'how do you drive a steam engine' will attract visitors.
	APE	LEE	ARaA		Engagement	Visitors will ask questions of the exhibit and look for answers to them.	Determine if the visitor asks questions and look for a answers	Opposite to I spy, the teaching aspect takes place in the beginning of the experience in the form of directions. Users may ignore this or pay attention. Users will learn while "figuring out" how to drive the engine- experimenting with the controls.
		LEE	ARaA	Cons.	Authenticity	Visitor will feel that the exhibit provides an experience of an authentic railway experience.	Ask if the visitor if they felt it provided a realistic train experience	This might be perceived as an in-authentic experience as it is a simulation of driving a steam engine.
	APE		ARaA		Open Ended	Allowing open ended exploration with 'gentle guidance' - not a scripted experience.	Determine if the visitor explores the exhibit without outside help.	This game is not very open ended. While the user can control the engine as he/she pleases, it only has
	APE				Self Driven	Minimizing instruction and explanation- encouraging visitor-initiated observation, speculation, play and construction.	Without giving the visitor systematic directions, see if the visitor can progress	The game will have to have a brief instruction period before starting - the user will have to figure out the rest of the controls.
	APE	LEE	ARaA		Participation	Visitor uses information from the exhibit during interaction.	Visitor uses information from the exhibit.	The user will be actively driving the train once the game has started- not receiving instruction or explanations.
		LEE			Connection To People	The exhibit creates a connection from the visitor to a family member, memory, or other social topic.	Look for conversations or statements regarding memories or personal stories	The game can include stories about the relationship between the driver and the fireman as well as historical information about how regular rail services shaped Britain
Acc.			ARaA	Cons.	Physical	Physical accessibility for disabled individuals means better accessibility for school groups and families.	See if the visitor can physically access the exhibit	The controls will be located at an accessible height. The game is limited to only as many players as there are control sets but people will have space to gather around.
Acc.			ARaA	Cons.	Visual	Best practice sensory accessibility allows more people to experience the exhibit.	See if the visitor can understand the directions and interface of the exhibit	The display of the race will be located considerably higher for more people to see.
		LEE		Cons.	Environment	Create a multi-sensory, immersive experience.	Ask if they thought that the lights and sounds added to the overall experience.	The cab is conveyed by a mockup of the control set, sound, and possibly other environmental factors such as heat, smoke, steam, etc.

Key

Abbreviation	
Acc.	(Accessibility) Disabled Discrimination Act, Best practice
APE	Active Prolonged Engagement
LEE	Life Enhancing Experiences
ARaA	Audience Research and Advocacy
Cons.	(Consultation) Student consultation with explainers

Appendix G: Prototype Testing Observation Sheet

"I Spy" Observations

Observer:_____ Time: ____ Date: _____ Target: _____ Age: ___

(in ad/school/family) (M/F)

What mood are they in when they arrive?	
Do the visitors understand the directions?	
Are they able to find the objects mentioned?	
What discussion is taking place between the group?	
Do they seem surprised by anything?	
Is everything accessible?	
What mood are they in when they leave?	

Appendix H: Prototype Testing Questions

Observer: _____ Exhibit: _____ Date: _____

Group: School/ Family/ Independent Adult M/F Age: _____

I'm _____. I am working on a project for the National Railway Museum and would like to know what you think about one of our future exhibits. If it is alright with you, we would like to take some of your time with some questions and a fun activity. Would this be okay?

Before we begin, I'd like to remind you that we are testing our ideas and concepts. Please note that this is not the final product. We hope these tests will make a better final exhibit because of your honest feedback.

What we will be doing is asking you to look at the engine called Duchess of Hamilton. After this we would like to ask you some questions about the engine and about an interactive game idea that we have for helping people to find out more about the engine.

We are researching new ways of allowing visitors to engage with the engines here in the museum. One concept that we have been exploring is allowing visitors to touch the trains to produce an audio/video response. This could include train noises, heat, lights, and maybe even steam! One idea we are currently testing is playing I Spy with the engine.

Now that you have had a chance to look at the engine we would like to ask a few questions about it.

Pre-Activity Questionnaire

1. What are your immediate reactions to the engine?

2. What, if anything, interests you about it?

3. What questions, if any, do you have about the engine?

1. When you started to play the game, were you expecting something that was not included?
    a. Probe: What would you have liked to see in this game?

    b. Follow-up: Could anything have been done differently?

2. What do you think this game was trying to accomplish?

3. Did you like the idea of playing I Spy with a train?
    a. Probe: What makes you say that

4. How realistic was this the activity? (scale of 1-5 with 1=not very 3=neutral 5=very)

5. Did anything in the game surprise you?

6. Who would you recommend this activity to? Is there a reason for this?

Appendix I: "I Spy" Prototype

I Spy

I Spy the headlights…

Unlike the headlights on your car that show you which way the road goes so you don't go off the road, these lights were not used in the same way because it might reflect off the signals and give the driver a false reading. During World War II they turned off all lights to avoid being spotted by enemy bombers.

I Spy the big wheels…

You may have noticed that this engine has 3 massive wheels located in the center on either side. These are the driving wheels; the other wheels are for stability and load distribution. The steam powered pistons turn these wheels to move the train forward. These drive wheels are 81in/2.06m in diameter. That's taller than most people! The other wheels range from 36in/.914m to 45in/1.14. In comparison the wheels on your car are only 25in/.636m.

I Spy the metal that connects the wheels…

This is called a coupling rod. These make the driving wheels turn together to create more traction by increasing the surface area of the wheels on the track and help prevent the wheels from slipping. Unlike the wheels in your car, these wheels can only slip if they slip together.

I Spy a nameplate with a date…

This nameplate tells when the cab was built. Designed by William Stanier, the engine was constructed at the Crewe Works facility in 1938. Unlike the original members of her class, the Duchess of Hamilton originally streamlined much to the displeasure of its designer, "Streamlining may be something like that blessed word Mesopotamia to the old lady. At any rate it has good publicity value."

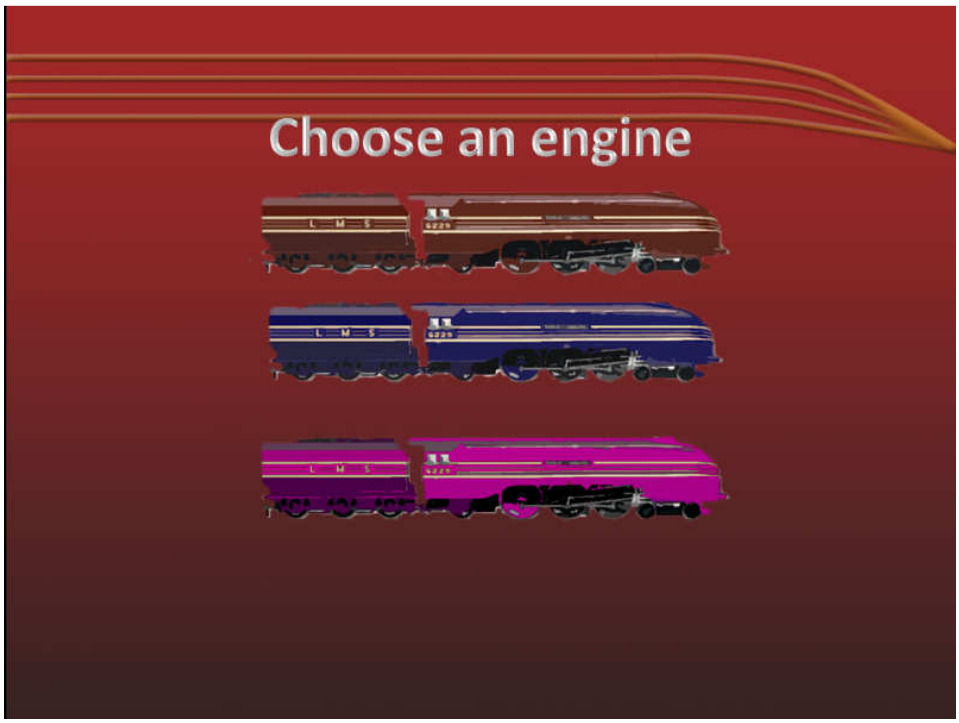
I Spy the metal steps to the cab…

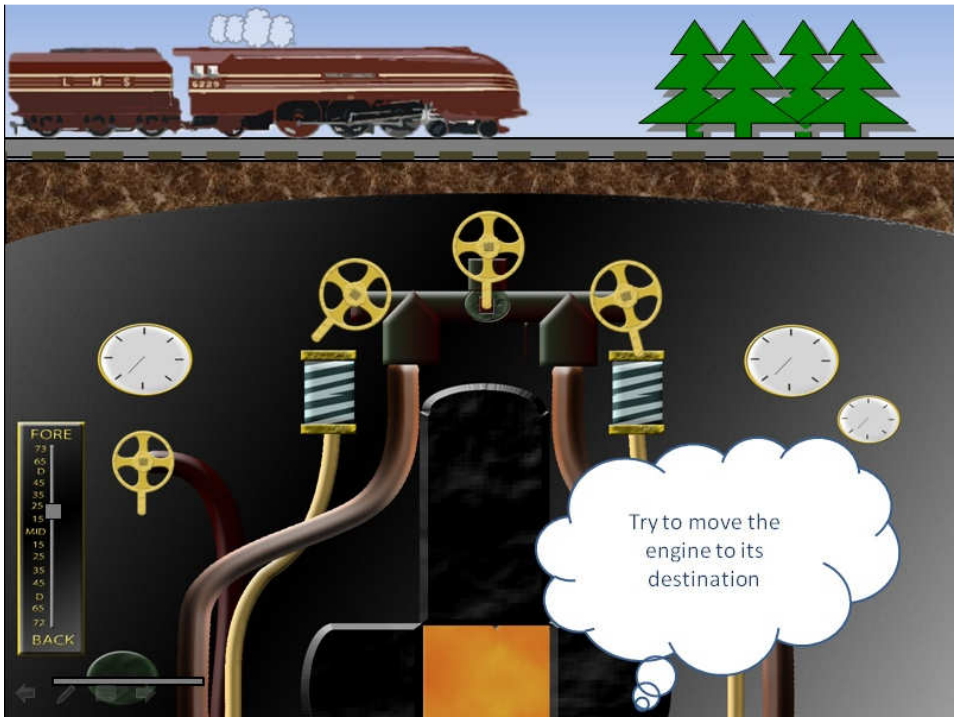
The driver and the fireman would use these steps to get into the cab for their shifts. Driving a steam engine was not an easy task. A driver and fireman working in complete unison through the blinding smoke, scorching heat, and restricted spaces manned each cab. The fireman's job was to shovel tons of coal hours on end to keep the train running. The driver's job was to keep the rest of the train on course and on the track. One slipup could mean instant death.

I Spy some buffers…

These are called buffers. Trains are not designed to function like bumper cars found at the fair. Collisions however do occur especially when linking train cars together. The buffers found at both ends of the engine are designed to absorb the shock of collisions preventing damage.

Appendix J: "You're the driver" Prototype




FORE
BACK
Try to move the engine to its destination

Appendix K: Summative Assessment

Summative Assessment

Student A's Assessment

Student C

In my previous assessment I said that Student C could work on his writing. I feel his writing has improved with the drafting of our findings section. His sentences now flow better and he uses less big words that might confuse people. Student C also went out onto the museum floor and did a majority of the prototype testing while the rest of us worked on our sections.

Student D

I previously stated that Student D should continue to get more sleep. He started taking naps after work which allowed him to be well rested every day. By getting more sleep Student D was able to work to his full potential. Student D drafted the introduction to our paper and rewrote sections of our literature review as our project goal changed.

Student B

In the previous assessment I stated that Student B cannot multitask to save his life. However, he can now type on the computer while telling him your thoughts about a sentence. Student B worked with Student D to rewrite the literature review when our project changed. Student B also put together our criteria matrix to evaluate our ideas on.

Student A

In our previous assessments I stated that I needed be more vocal in our meetings with advisors and the museum staff. By the end of the project I was speaking during all of our meetings. One of my contributions to the project was drafting the methodology section. Another way I contributed was by gathering all of our appendices and made them fit into the paper.

Student D's Assessment

Student C

Student C contributed immensely to our prototype testing. We identified his interpersonal skills early on in our assessment. These elements shined in prototype testing where getting visitors will to help was a challenge. Student C's goals from the previous formative assessment were to improve writing quality and to continue working being less direct with friendly questioning. In both of these areas he has improved. He is making less of the grammatically seen previously and pointed questions were no longer issues.

Student B

Student B used his organizational skill to take the lead role in developing a matrix summarizing our entire project. He was able to take the ideas discussed as a group and format the massive amount of information into a presentable table. His editing skills were highly useful as our project came to an end. The recommendations made to Student B at the conclusion of the last assessment included working on multitasking and encouraging other members of the group to speak up during meetings. He has made a slight improvement in the area of multitasking and more prominently has promoted others to lead discussions as well.

Student A

Student A was key finalizing and developing our methodology. His input formed the base upon which our project developed. In addition to this, later on in the project he was the driving force behind the testing questions used to assess our prototypes. Through these contributions Student A has affected our project for the better. Student A's recommendations were for sleep and to speak up more. In both these areas he has improved. As he has become more familiar with those we work with he has become one of the more talkative members of the group. Unfortunately with impending deadlines, sleep did not improve as much.

Student D

I have aided the project in several areas. I took the lead in developing the prototypes to be tested. In addition to this I edited much of the paper for grammatical and spelling mistakes. My team recommendations were to get more sleep and to work on my

speaking skills. In both areas I feel have improved, going to bed earlier and leaving out place holders in presentations.

Student B's Assessment

Student A

In my previous formative analysis, I stated that Student C had been "checking out" during literary revising and review sessions. This was only a temporary temperament. When it came time to prototype testing, Student C really stepped up. He did nearly all of the prototype testing with visitors and wrote the Findings section of the paper. This was a large portion of the work and the Findings section came together well.

During our presentations and meetings in the final days of the project, Student C spoke clearly and thoughtfully. This was an improvement over earlier public speaking and unscripted presentations where he would occasionally be unclear and vague.

Student C

Student A did a good job of being more vocal during team meetings. Early in the project, he would remain quiet during meetings involving our sponsor and ask questions or bring up problems to us, his group members, only after the meeting had adjourned. In the second formative assessment I wrote that he had improved, but that I would like to see even more participation. Student A improved his participation in these meetings throughout all seven weeks.

For our paper, Student A took the lead in the Methodology section. He wrote much of the initial text and did much of the revising from the comments and corrections from our professors. Over the course of the project, his writing significantly improved, and while we still edited the section as a group, the number of changes was significantly less when compared to his writing earlier in the project.

Student D

In terms of the formative analysis, Student D took the comments the group made about his sleeping habits to heart. He recognized that his participation was affected during work and that his grogginess negatively affected our group image. Student D started taking naps in the afternoons in addition to sleeping more at night.

For the paper, Student D served major roles as both a writer and an editor. He wrote a significant portion of the literature review and together, him and I served as editors for our group members.

Student B

I improved on my multitasking skills. In previous formative assessments it was clear that my inability to engage in two separate activities simultaneously slowed the group down. I feel that, while I haven't completely overcome this shortcoming, I have significantly improved. In response to balanced participation in group meetings, I have drastically stepped back to allow other, less aggressive group members to speak. In addition to stepping back, I have taken more opportunities to encourage group members to speak- specifically inviting them to join the conversation and share their ideas and opinions.

For the paper, I served a similar role as Student D. I was both a writer and an editor. I wrote the much of the literature review with Student D and I served as an editor for the other group members. In addition to this, I constructed and later edited the matrix, which we used to organize our projects and served as the outline for both our literature review and methodology.

Student C's Assessment

Student D

Student D has set workflow pace since the beginning of this project. He has been able to complete his work and was of much assistance to his colleagues. He essentially wrote the introduction that was peer reviewed before submission. Also he worked with Student B to restructure and edit the literature review. By doing the work together, they were able to accomplish this task with great efficiency.

Student B

Student B demonstrated how a leader should be throughout the course of this project. He led meetings and was generally the first to answer any questions to our group from our sponsor or advisors. During the project, Student B most notably created the matrix which helped in producing prototype exhibits. Also, he worked with Student D to restructure and edit the

literature review. Working together enabled them to decrease the time it took to complete this task while building teamwork.

Student A

Student A has been a very diligent worker that gets his work completed in a timely manner. He spent a lot of time experimenting with the features of Word 2007, to make sure it had the correct and expected format. This included taking parts that were previously part of the literature review and methodology that ended up in the appendix at the end of the final paper. He also did majority of the editing of the methodology

Student C

Student C has been able to break the ice when we met new people. This helped tremendously as it allowed us to cope with the culture shock and separation from the rest of the London E'10 IQP group. For this reason, Student C did majority of the prototype testing as it was easier for him to approach visitors and request them to partake in activities. Towards the end of the project, Student C was able to create a working copy of the Findings section for peer review. This made it easier on the group as they were able to work off of this section and make changes accordingly.

Team Assessment

In our previous team assessments we noted the need for greater peer review. Often times we would divide work to accomplish assignments more efficiently. While this division of labor led to the completion of greater amounts of work, some sections suffered as a result. In response to this we incorporated several new strategies into our working process. Whenever possible we would display the current sections of our work on a projector for the whole team to review. Unfortunately, such accommodations were not always possible. To help us in this area we discovered software which enabled us to edit our documents simultaneously. This helped our peer reviewing immensely in the final days as we would watch the changes being made instantaneously and give feedback. We were consciously aware of the need to work on this area and in preparation for our final report we went on a nearly twenty hour marathon peer editing our work in its entirety, stopping only briefly for food. We feel this has greatly benefited the final product.