Digital Education Evaluation

The Future of *Time Lens* at the Melbourne Museum

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Abstract

The Melbourne Museum, the most visited museum in Australia, asked the project team to determine the effectiveness of their scavenger hunt mobile application *Time Lens Episode I: Treasures and Gems,* as well as design a course of action for a new mobile application. The evaluation of *Time Lens* was used to determine if future family-based mobile applications were viable and desirable for use in the Melbourne Museum. The team observed the use of the application and discussed its effectiveness with families, staff, and peers. Based on these discussions the project team constructed plans for a future application for use at the Melbourne Museum. Our final recommendations also include plans to promote mobile technology within the museum.

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Our student peers working on projects in Melbourne participated in our evaluation. We appreciate them taking time out of their project schedules to provide feedback crucial for completing our project.

Executive Summary

Goals and Objectives

With the advent of widespread mobile technology in daily life, businesses and organizations are starting to incorporate this technology to gain a foothold in the increasingly digitized world. Museums and other cultural institutions are not immune, and in their latest adaptation have started developing mobile applications to help enhance the visitor's experience. The goal of this project was to evaluate the effectiveness of Museum Victoria's mobile application *Time Lens Episode I: Treasures and Gems* and generate ideas for a new application to be developed for the Melbourne Museum.

Methods

Our team researched common evaluation practices and determined the most effective way to complete a successful summative evaluation. To accomplish this, we familiarized ourselves with the Melbourne Museum, the current *Time Lens* application, and the previous formative evaluation that had been conducted about the application. We also interviewed six staff members to gather opinions about the current version of the application. Next, we assessed the experience *Time Lens* created for both member and non-member visiting families and solicited critical appraisal from our peer group of WPI students. We recruited a total of thirteen member and non-member families to trial *Time Lens* and provide feedback. We observed most of the families using the application to judge the quality of their experience.

We presented our initial findings to a small group of staff involved in the development of *Time Lens* and to Museum Victoria's Online Planning Group. We then designed a new application continuing the *Time Lens* brand, drawing on inspiration from the results of the previous formative evaluation, our summative evaluation, and staff recommendations. We storyboarded our designs using both hand-drawn sketches and the FluidUI Prototyping Program[1]. These storyboards included themes and narratives, as well as sample content for featured objects. We presented our evaluation findings, design plans for a new application, and additional recommendations about digital applications for the museum to pursue. Our final recommendations for future development of the new application included objectives and goals, possible themes, options for the interface, and additional features.

[1] FluidUI - FluidUI is a browser-based web application that lets you prototype applications for touch screen devices. (FluidUI Welcome Comments, 2013)

Evaluation Findings

We found that both member and non-member visiting families overall had a positive opinion of *Time Lens*. They found the content and quality of animations enjoyable. Many families commented that the application gave a new perspective to their museum visit. During a standard museum trip, parents usually directed the family group from one gallery to the next, but when using *Time Lens* children took the lead. This altered the family dynamic and cut the average length of the visit nearly in half. Despite some issues, *Time Lens* received mostly positive reviews from visiting families during our summative evaluation, and our group determined it was successful at entertaining and educating families with young children.

When we discussed *Time Lens* with our fellow WPI peers, the reviews were mixed. The rudimentary map in the application did not help the peers navigate the unfamiliar galleries in the museum. They desired more structure and guidance within the layout and directions of the application. Our peers also felt the badge system was poorly organized. They did however enjoy the animations, claiming they were appropriate for the target age group of six to ten year olds. Additionally, they commented that the application encouraged the user to learn more about the museum objects it featured. The majority of our peer group suggested that *Time Lens* should guide visitors through their journey to reduce confusion.

After we completed the summative evaluation, our team was originally instructed to design an application for an upcoming exhibit at Museum Victoria's Scienceworks venue. Due to construction constraints, the second part of our project was altered to instead design another application for the Melbourne Museum. Using the previous formative evaluation and our summative evaluation results, as well as staff opinions and a review of other mobile applications, we determined the best course of action for a new application.

Recommendations for the New Application

We recommend that the Melbourne Museum continue the *Time Lens* mobile application series by creating *Time Lens Episode II: The Curator's Collection*. The new application will not seek to replace the current version of *Time Lens*, but serve as a companion that builds on the foundation of the current application. This second episode in the *Time Lens* series encompasses every gallery within the museum, with the exception of the touring gallery and any other galleries the museum may deem unsuitable for the targeted age group. We envision the application as an explorative,

collection-based adventure primarily aimed at children eight to twelve years old. We believe this demographic is less engaged by other museum programs and we would like to capture their attention with an exciting new application. We propose that this includes questions varying in difficulty level to appeal to a range of learning levels. The current version of *Time Lens* included animations, which were well received, but we feel that removing these from our plans will simplify the storyline and reduce the application file size.

Based on peer suggestions, we recommend that the next application move away from the dark, bare scheme and incorporate a brighter, more tropical palette. In accordance with a more explorative theme, our team proposes introducing a new character entitled the Courageous Curator, who would mirror classic adventure characters portrayed in films and books. The user would help the Courageous Curator collect items for his gallery by locating objects throughout the Melbourne Museum. Users would also have a customizable collection of their favorite museum objects collected in the application. As a result of families' desire to have the protagonist play a larger role in the narrative, *Time Lens* would feature the Courageous Curator more often.

Many participants in the summative evaluation requested more content, either in the form of challenges or more content from each gallery. Our design for the new application includes more galleries than the current *Time Lens,* with every permanent gallery represented, and more objects represented in each gallery. This would particularly appeal to Museum Victoria members who visit frequently and are constantly seeking new ways to enjoy every gallery.

Families with children of substantially different ages (i.e., more than 3 years difference) suggested an application with multiple difficulty levels since the content was too difficult for young children, but too simple for older children. In the new application, we propose three questions ranging in difficulty for each featured object. If a user answers the first question (beginner level) correctly, they would add the object to their collection shelf. The second and third questions (intermediate and expert levels) would give the user points towards the Silver and Gold Museum Medal respectively. The challenging questions are not necessary to continue on to another object, allowing younger children to still complete their collection of objects. Varying difficulty levels accommodates both ends of the target age range. Bluetooth technology would also be

included, using Estimotes[2] on exhibits to assist in way-finding. Several objects not contained in the main museum galleries would become 'smart objects' using Estimotes. These objects would prompt application users who have Bluetooth-enabled to answer optional questions as the visitor passes by the object.

Many families remarked that the application was susceptible to cheating, further curtailing the length of time taken to complete it. Our team traced this problem back to two major issues: questions could be solved without needing to actually see the object and rhyming riddles were too simple to solve. Both parents and peers desired a way to validate that the group had arrived at the correct object to inhibit cheating. The beginner question mentioned above will ask a physical detail about the object, which would require the user to see the object, and this would hopefully remove the temptation to cheat. In the current version of *Time Lens,* we noticed that not many families utilized the journal tab that contained every object the user had found. We want to encourage users to review information amassed during their visit by creating the collections gallery. This page would contain all the objects that the user has gathered on a virtual shelf. Each individual gallery would have its own shelf and missing item cards would be present for objects that have yet to be found and collected. Users can then click on an object in their collection to review information about it.

Some families were discouraged from hunting for objects in the current application since it lacked a user-friendly interface and understandable navigation tools. Our peers also struggled navigating due to the lack of detail in the map. The map in the new application would have more detail and be zoom-capable to address issues found in our evaluation. Instead of tiny pins on a static map featured in the current version of *Time Lens*, icons and color-coding would be used to differentiate each gallery. Visitors who are unfamiliar with the museum would also be able to use the application through the use of this enhanced map. The interface of the application would be streamlined and game-like, including bigger buttons in the main menu and buttons to return to the map while completing questions.

Further Recommendations for the Museum

We recommend that the Melbourne Museum continue the *Time Lens* brand for marketing purposes. It would be easier to promote an application that builds on the

[2] Estimote is a small, wireless device that broadcasts tiny radio signals to smart devices. They can be used to track location, temperature, and speed. (Estimote Beacons Real world context for your apps, 2013)

foundation of the previous *Time* Lens and creates a branded series of applications. For this new application to be successful in the museum, it must attract visitors and appeal to audiences through effective marketing strategies. Informed customer service staff and promotional signage throughout the museum would encourage visitors to trial the application. Some museum members who participated in our evaluation did not even know *Time Lens* was currently being used in the museum. The future application could be more successful and popular if it received more attention. We recommend that the museum take a stronger approach to marketing its various digital applications. This could include advertisements on the Museum Victoria website and social media sites.

Mobile applications are a still relatively new phenomenon and museums are still determining whether they are truly beneficial to a visitor's learning experience. There is debate about whether applications like *Time Lens* enhance or distract the visitor from physical museum exhibits. Our observations confirmed that the application shortened the length of the average museum visit, but the museum needs to conduct more evaluations and studies to determine how effective mobile applications are at positively enhancing a visitor's overall experience. From our own evaluation, we found that most families felt they learned something new by using the application. This is our basis for encouraging the museum to create a new and improved mobile application.

Should the museum choose to follow our recommendation for the new application, we recommend that it be made to function on mobile devices. More and more people own smartphones and prefer to use their personal device for such applications. If the museum were to implement a device loan program, it would likely be costly and require constant maintenance. Visitors who have an interest in using mobile applications are likely to own a smartphone that the application would be compatible with. However, it would be wise for the museum to have several devices with the application pre-loaded to loan in the case that no member of the family has a smartphone and still wishes to use the application.

To more easily review the application, a brief five to ten minute survey will be built into the application. This would allow the museum to quickly and easily collect feedback and gauge visitor satisfaction without needing to execute a lengthy evaluation process. Since the applications plans to trial emerging Bluetooth technology, it is important to gather opinions about its effectiveness.

Mobile applications are the latest adaptation in the evolution of museum learning strategies to engage visiting audiences. The Melbourne Museum should develop *Time Lens Episode II: The Curator's Collection* to build on the foundation created by the

previous Museum Victoria mobile application. While museum mobile applications are still relatively new, we believe that the Melbourne Museum should firmly establish itself as a more modern museum and continue to adapt to the technology.

Authorship

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Victoria Fleek acted as primary editor and compiler for the entire report. Ellen Pierce edited and compiled references.

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1. Introduction

Museums have embraced new ways to engage visitors and enhance their experience by developing hands-on, interactive exhibits that promote inquiry-based learning. Static exhibits with text panels have been replaced by technologies that provide multi-sensory stimulation and extend the learning experience by implementing interactivity. Digital technologies have played a prominent role in the evolution of the museum environment and museums are increasingly employing mobile applications to engage visitors.

Tallon (2013) found that 43% of museums surveyed utilize some form of mobile technology, representing a 10% increase since 2011. An additional 23% of museums plan to implement mobile digital technology in the future (Tallon 2013, Tallon 2011). Nevertheless, the use of mobile technology to interpret exhibits, improve way-finding, and enhance the visitor experience remains a work in progress. Methods to efficiently and effectively engage and teach without distraction or over-simplification still need further research. Although some studies have been conducted to determine how mobile technology influences visitors, this process is still being refined. Our engagement with the Museum Victoria organization helped us begin our own evaluation process as we worked to expand digital technologies used in the Melbourne Museum.

The Melbourne Museum, the flagship location of the Museum Victoria umbrella organization, is a modern museum that opened at its current location in 2000. The museum artefacts and exhibits cover a broad range from natural history and science to local history, including the new Bunjilaka Gallery that focuses on the history and culture of Aboriginal peoples. The modern, open design of the museum is fresh and simple. While still working to maintain and embellish its current galleries, the museum has implemented many interactive strategies including fixed digital technologies in galleries.

The museum is also experimenting with different ways to use mobile applications to supplement their exhibits and improve the visitor experience. The museum has developed an application entitled *Time Lens Episode I: Treasures and Gems* featuring puzzles and riddles for young children to solve as they venture throughout the museum. The application is presently available for use at the Melbourne Museum, but the organization would like to develop a companion application modelled after *Time Lens* for the museum to further expand its digital application collection.

The goal of this project was to evaluate the effectiveness of the current *Time Lens* application and generate ideas for a new application to be developed for the

Melbourne Museum. Our team researched common evaluation practices and determined the most effective way to complete a successful evaluation. We evaluated the experience *Time Lens* created for member and non-member visiting families and solicited critical appraisals from our WPI peer group. We selected appropriate themes and suggested adaptions for a new application based on the results of our evaluation and interviews with museum employees. Recommendations for future development of the new application included objectives and goals, possible themes, and options for the interface and additional features. These recommendations were passed to the museum to develop the new application in the near future.

2. Literature Review

Museums have changed dramatically in recent decades in response to feedback from visitors and advances in learning theory. Instead of traditional methods of transmitting information, learning theories now encourage a constructivist method that conveys information in multiple ways. Many museums, especially science and children's museums, are no longer filled with static exhibits, but are vibrant places with hands-on, interactive exhibits that promote inquiry-based learning.

An innovative wave of digital technologies has sparked new approaches to social interaction and learning. These technologies play an increasingly important role in museums, from exhibit design to online ticket sales. Mobile technology is one of the most recent products of this exciting revolution. As mobile technology becomes more affordable and available, museums are exploring new ways that visitors can interact and engage with exhibits via mobile digital applications.

2.1 The Modern Museum

The American Alliance of Museums states the goals of museums as follows:

> Taken as a whole, museum collections and exhibition materials represent the world's natural and cultural commonwealth. As stewards of that wealth, museums are compelled to advance an understanding of all natural forms and of the human experience. It is incumbent on museums to be resources for humankind and in all their activities to foster an informed appreciation of the rich and diverse world we have inherited. It is also incumbent upon them to preserve that inheritance for posterity (Code of Ethics for Museums, 2000).

Accordingly, museums have three primary roles: collecting objects, conducting research, and educating visitors. Museums achieve their educational role through exhibits and programs, but must compete for audiences with myriad other edutainment options. Thus, modern museums have become places of interactive exhibits and gift shops that allow for participation, interpretation, and consumerism (Edson & Dean, 1994). The modern museum is “recreation-focused” rather than purely educative, and the future museum is likely to present a hybrid of recreational and learning opportunities (McPherson, 2006).

Modern museums aim to blend entertainment and education - but how do they accomplish this successfully? Museums must attract and engage visitors. Hands-on learning is booming in the museum environment, as it is increasingly becoming a staple approach in modern educational practice. Increasingly digital technologies are being used in exhibits to enhance engagement, encourage interactivity, and even create immersive experiences. Total immersion enhances learning while simultaneously stimulating visitors (Barry, 2006). For example, the *High Arctic* exhibit installation at the National Maritime Museum in Greenwich, England seeks to "immerse museum visitors" in an individualized expedition (Ntalla, 2012). From this experience, museum visitors can better picture the Arctic landscape and imagine all that would be required for such an excursion. This interaction can "encourage questions and understanding" in a broader context (Ntalla, 2012). Such experiences encourage social engagement and helps cement the museum experience for visitors.

Research indicates that visitors have a better grasp of factual information presented in an interactive exhibit, rather than if the information had been presented to the audience without such an experience (Ntalla, 2012). In a study conducted on the use of mobile applications, sixty students between the ages of 15 and 16 were evaluated after using a mobile-based educational application at an art gallery. The application included QR codes[3] and a quiz. Some students were also given a paper version of the game to complete for comparison. Results of the study indicate that the mobile application "benefits students' performance in a highly significant way" (Mikalef, Giannakos, Chorianopoulous & Jaccheri, 2012). The study also concluded that students enjoyed their visit when using the game-based application and comprehended more as a result. Although similar studies are only now surfacing, this evaluation supports claims that interactivity created by mobile applications bolsters learning in a museum environment.

2.2 Learning Styles

To continue pursuing their objectives, museums must keep up with an ever-changing society and educational system. The organizations that are adaptable and show interest in keeping up with such demands are more likely to be successful and attract visitors. Lessons learned from visitor studies, exhibit evaluations, and research on

[3] QR (Quick Response) Code – "A two dimensional code bar code that is widely used to cause a Web page to download into the user's smartphone." (PC Magazine, 2013)

informal and free-choice learning have greatly affected museums. Current visitors are more demanding, spanning different learning styles, knowledge levels, and experiences.

Museums, like those in the Museum Victoria organization, must find new ways to address and implement changes to keep their locations fresh, engaging, and appealing to all visitors. Thus, Museum Victoria focuses on “fascinating … and interactive” exhibits that appeal to a greater audience (Museum Victoria, Annual Report, 2012). Museums have learned to appeal to diverse audiences with different interests and learning styles. Impacted by their own evaluations and changes in education research, museums are working to cater to visitors. Museums that allow for independent thought and exploration embrace new learning styles that differ greatly from traditional approaches.

Museums allow visitors to explore information, creating an environment with multiple approaches to learning. Rather than following a set time and course structure like most schools in the formal education sector, museums allow for open learning that mirrors community learning. This allows visitors to break away from the “obedience” of formal teaching and adventure in their own way (Dewey, 2007). Referred to as multiple intelligences, the need for alternative learning styles comes from research suggesting mental capacities vary from person to person. The variety of intelligences can be categorized into different strengths such as linguistic or logical-mathematical intelligence. The learning style most suited for each intelligence type reflects the person's central strength. For example, someone with linguistic intelligence learns most effectively by verbal communication from an educator (Gardner, 1993).

Museum or ‘free choice’ learning is considered informal and voluntary. Unlike a school environment, museum learning depends on the individual visitor’s interests and has a less formal structure. The visitor selects what he or she wants to learn, and to some extent the way in which they want to learn. Museum learning is also mainly affective, as opposed to cognitive learning. The learning is affective because it influences feelings, interests, or attitudes of the subject matter (Lord 2007). Affective learning experiences are stimulated by the objects in the museums, whether they are works of art or live specimens.

2.2.1 Child Learning

Museums must also consider the learning styles of children who visit the museum. Since museums seek to educate, children are a crucial target audience. Different age groups of children have particular learning styles and interests. Children aged four to seven are considered in the “preoperational” stage (Lord, 2007). They are questioning many things and are seeking concrete answers. They are starting to

conceptualize and enjoy make-believe play. Learning is best accomplished through activities that use physical tools and hands-on specimens to teach.

Children aged seven to twelve are typically in the concrete operations stage, with good motor, verbal, and mental skills they enjoy facts and information, and can operate on their own for long periods. In this stage children start asking why, how, and when questions. Children at this stage “need to find out as well as do” (Lord, 2007). Museum galleries targeting this age group should act as areas of exploration and contain objects that can be physically examined or measured. Films and videos are also useful to convey information about museum objects for this age range.

Piolano, Hisland, Ruffeveille, Jambaque & Eustache (2007) conducted research on the Remember/Know Paradigm to determine the differences in autonoetic and noetic consciousness in children ages seven to thirteen. Autonoetic consciousness refers to memories the child ‘remembers’ while noetic refers to simply ‘knowing.’ A child was capable of ‘remembering’ an event if they were able to describe the event, including time and place. Such memories are known as episodic memories because they apply to a specific event in time. ‘Knowing’ an event meant the child’s response was based on historical context rather than personal memory. The children were asked to recall events from the current academic year, the last academic year, and previous school years. Results of the study indicated as a child aged, their episodic memory increased. Older children were able to recall and describe personal events more descriptively. The study also concluded that children had more ‘remember’ responses with better justification and lower ‘know’ responses with increased age (Piolano, Hisland, Ruffeveille, Jambaque & Eustache, 2007). This information is important for museums since they must create exhibits that cater to various ages and developmental stages.

2.2.2 Family-Centred Learning

For a museum exhibit to achieve its intended goals, it must cater to a wide array of interests and abilities. Many people visit museums in friend or family groups, often seeing it as an interesting, fun, and social activity (PISEC, 1998). Reasons for visits range from building shared memories to gaining educational benefits (PISEC, 1998). Groups often learn collaboratively, increasing not only their amount of learning in the museum but also learning more about each other. Parents who bring their children for visits often view museums as a good environment for children to absorb knowledge beyond the classroom (Falk and Dierking, 2000). Visiting as a family unit opens up opportunities for both independent and collaborative learning. Adults are comfortable

sharing their previous knowledge with children, while children have the opportunity to explore exhibits and process new information on their own.

Modelling and social learning occur while family members interact with each other. Members of the family learn the content in their own way. Young children may touch interactive objects while an adult spends time reading provided information. Group discussion stimulates other opinions and thoughts about the information, allowing a family to learn more about the exhibit because each individual has a different perspective to share with the group. Families also participate in the "Conversational Elaboration," meaning that discussions that occur during a visit and continue afterwards encompass many different experiences, meanings, and interpretations that each person has constructed (Falk and Dierking, 2000).

The PISEC (Philadelphia-Camden Informal Science Education Collaborative) study was performed to determine what families learned in museums and how the visitor learning experience might be enhanced. When exhibits were designed around social interaction, family groups learned more from the exhibits because they were able to discuss the exhibit with other family members who may have had a different interpretation. The study identified seven factors that increased family learning. Exhibits should be multi-sided, multi-user, accessible, multi-outcome, multimodal, readable, and relevant (PISEC, 1998). Exhibits that have these qualities are more conducive to family-oriented, social learning because they encourage the family to talk and discuss the exhibit amongst their group.

The National Museum of Australia looked closer at family groups visiting museums throughout the nation. Australian families have started demanding separate spaces for young children that promote "hands-on learning … curiosity and creativity" in an explorative environment (Kelly, 2011). In response, museums across Australia have designed spaces for constructive family interaction. The Australian Museum in Sydney created the *Discovery Room*, *Search and Discover*, and *Kid's Island* in the late 1990s as some of the first interactive exhibits for families and children. The exhibits allowed children to explore and discover in an open environment, while incorporating past collections and research from the museum. The Melbourne Museum later created the *Children's Gallery* aimed at three to eight year olds in an effort to "encourage discovery and exploration" in science-related fields (Kelly, 2011). In both museums, parents learned alongside children while sharing knowledge.

2.3 Changes in Exhibit Design

As Hein (1998) explains, traditional didactic approaches to learning in museums have shifted to increasingly participatory methods based on behaviourist and constructivist learning theory. Behaviourism focuses on behaviour as a science understood by the stimulus-response method, while constructivism encourages active participation and creation of meaning. Both of these methods place great importance on the visitor's feelings and involvement with exhibits. In the past, museum exhibits and programs emphasized didactic teaching methods based on the concept of incremental learning and outside knowledge (See Figure 1). Traditional, didactic exhibits have a strong sequential flow with clear beginnings and ends and an assumed logical structure (e.g., chronological or developmental). Labels and panels explain what is to be learned, and the exhibits are arranged in a hierarchical format ranging from simple to complex (Hein, 1998).

This approach parallels formal school settings, where a specific curriculum is presented and taught in chronological order. Didactic methods assume that people learn most effectively by "absorbing information that has been transmitted to them" (Hein, 1998). Accordingly, this style is called the 'transmission-absorption model' of learning, where small bits of information are relayed in a step-by-step fashion. These directed approaches may not be effective or satisfying for many individuals and groups, however, since learning styles and motivations for visiting museums vary widely (Falk and Dierking, 2000).

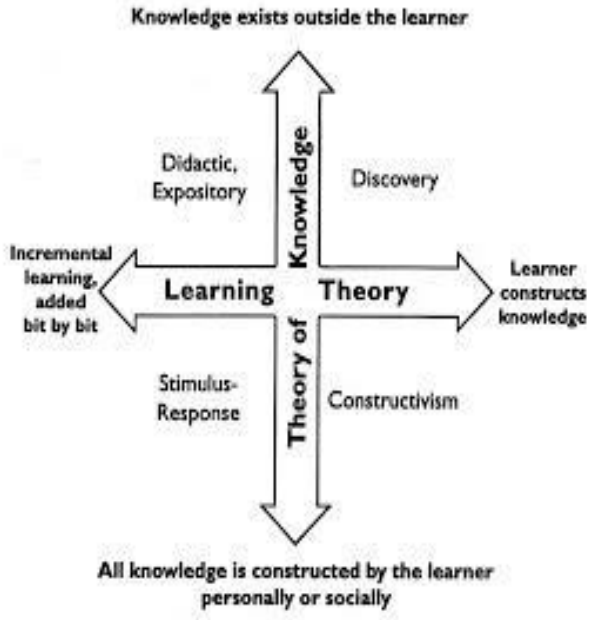

Figure 1: Hein's four types of teaching methods (Hein, 1998)

Other learning approaches are used independently or in combination to enhance visitor engagement, learning, and satisfaction (See Figure 1). The stimulus-response method has similarities to the didactic learning method, but provides positive reinforcement after displaying pertinent knowledge regarding the subject matter. This reinforcement ingrains information in a visitor's mind, enhancing their learning experience. Another method called discovery learning focuses more on interaction. Discovery-based exhibits allow visitors more freedom to explore the subject matter on their own. While didactic labels are still used to convey 'correct' interpretations of exhibit elements, more importance is placed on personal interpretation. This method allows visitors to "contemplate and consider" exhibits that are engaging and encourage hands-on learning (Hein, 1998).

Museums are adopting more participatory learning methods that allow content to be conveyed in a multitude of ways (Simon, 2010). Learning requires "active participation of the learner in both the way that the mind is employed and in the product of the activity" (Hein, 1998). This view of learning is incorporated in the theory of constructivism, which states that people "construct knowledge and meaning from their experiences" (University of Sydney, 2011). Constructivist exhibits have many entry points, present multiple points of view, cater to a wide range of learning modes, and provide materials that allow visitors to experiment and integrate their experiences from existing knowledge (Hein, 1998).

A constructivist museum can use a number of different strategies to promote learning, as the individual visitor prefers. One way is to add interactive exhibits or material. When successful, the interactive elements supplement the didactic content, promoting the opportunity for a learning experience that is unique to a visitor (Simon 2010). Museums also use constructivist websites to reach out to visitors. The website provides easily accessible information about objects that the museum offers at a physical location. This encourages participation in the museums because they can display those physical objects that the visitor has already read information about and is interested in online. Unlike didactic approaches, the participatory and constructivist approaches provide opportunities for those who learn in alternative ways to gather, process, and absorb information.

2.4 Interactivity in Museums

While museums have spent a great deal of time attempting to better understand various learning styles, they are also trying to address the concerns and desires of

modern visitors. Museum visitors are constantly exposed to various forms of media in their daily lives. This constant stimulation has created people who have the potential to absorb large amounts of information, but often lack continued focus and interest (National Institute of Mental Health, 2012). Accordingly, educators in museums and elsewhere highlight learning as an active restructuring of the mind (Hein, 1998). Museums have taken steps to better understand how interactive learning engages students and highlights different forms of participatory learning and teaching.

A museum's main attraction is its collection of unique objects that have cultural value. Museums have an advantage over books and the Internet in that they allow visitors to connect with physical objects (Teixeira, 2009). Modern museums around the world have started to realize the benefits of interactive exhibits. The Exploratorium in San Francisco, California has been one of the leading proponents of interactive exhibit design. With funding from the National Science Foundation, the Exploratorium conducted a four-year project to "explore strategies and tactics to shift the role of visitors from passive [recipients] of information to active [participants] in the exhibit experience" (Exploratorium, 2013).

The Exploratorium found exhibits that promote active prolonged engagement (APE) encouraged visitors to spend more time at the exhibits and increased visitor engagement and learning. In their final findings, the researchers identified major indicators to determine if an exhibit engaged visitors. Indicators included spending more time at each exhibit, asking questions about exhibits not explained completely in the label, and engaging in conversations with other visitors about the exhibit (Exploratorium, 2013). These APE exhibits draw visitors' attention immediately through a visually attractive design. Visitors are then exposed to extended periods of interactivity that inspire exploration and experimentation. This fosters a meaningful and effective learning experience for visitors.

Visitors are more interested in museum objects that are interactive, rather than those that simply sit behind a sheet of glass. Non-interactive exhibits tend to disengage visitors, especially teenagers and children. Long, complicated text labels presenting information divorced from everyday life discourage visitors from reading and engaging with the object. Most modern museum guests want to touch, explore, and connect with the objects on display (Teixeira, 2009).

Teixeira (2009) identifies seven characteristics that make objects more desirable in a museum exhibit: uniqueness, resolution of information, density of information, scale, authenticity, value, and nostalgia. Objects with high resolution and density of information

often provide substantial sensory details. Popular museum exhibits typically include objects that exemplify several of these attributes.

The magnificent mounted specimen, Phar Lap, is an example of an exhibit in the Melbourne Museum that embodies several of Teixeira's characteristics that make some museum objects more attractive than others. Phar Lap was a legendary racehorse that acted as a beacon of hope for Australian people struggling during the Great Depression. He was one of the most successful Australian racehorses in history until his untimely death under suspicious circumstances (Museum Victoria, 2013). Not only is Phar Lap unique, authentic, and priceless, but also he is also large and evokes memories of a previous time. Of course, Phar Lap may be more evocative for older visitors to the museum, but it is likely that even children may have heard stories of his exploits.

Museums face the challenge of creating exhibits that have immediate visual attraction and promote prolonged engagement. Exhibits that are sensory-driven help visitors understand objects in the context they are presented (Black, 2005). Previous studies have concluded, "hands-on, minds-on, and hearts-on [exhibits] best captivate visitors" (Dahl, 2012). Well-designed, interactive exhibits not only entice visitors, but also encourage them to probe for deeper connections. Museums are encouraged to allow for "open-ended, non-guided" visitor experiences that allow visitors to ask deeper personal questions and thus make longer-lasting connections to objects and exhibits (Dahl, 2012). Museums are increasingly using digital technologies to achieve this end.

2.5 Digital Technologies in Museums

Digital media that assists the pursuit of knowledge has an ever-growing presence in museums. In the late 1990s, technologies that enabled digitalization in museums expanded. Advancements started with simple devices such as audio devices that provided hypertext to visitors who used them. This supplied additional information and an alternative way to pass information to those with alternative learning styles. It was also an inexpensive way to provide a new, guided experience that did not require tour guides. Non-mobile digital interactive devices began to appear in museums in the mid-2000s. These gave explorative learners a chance to learn more about the objects on display. Although effective, these technologies had the disadvantage of breaking down and requiring constant maintenance.

Developments opened the door for exploration of other digital opportunities. The use of digital technologies in museums can range from exhibit interpretation, web outreach, online learning, and way-finding within galleries themselves. The increased

presence of digital media in museums caused the re-evaluation of traditional museum goals and how to achieve them. While museums are typically considered places one goes to look at exhibits, by 2002 the number of visitors to museums' websites had surpassed the number of people physically visiting the museum (Hawkey, 2004).

An example of digital media in museums can be seen at the Victoria and Albert Museum in London, England. Visitors were provided with the tools to construct digital images of the various exhibits and virtually insert these images into the exhibits themselves. Another project allowed visitors to use software to edit images taken with cameras in the museum, inspiring the creation of a personal experience to remember the exhibits (Hawkey, 2004). This personalization allows for a connection, enhanced beyond simple digital displays. This creates a more constructivist approach for learning since visitors are creating their experience, as opposed to an unchanging exhibit. Photo capturing creates a two-way interaction between the user and the exhibit, rather than remaining static and traditional in style.

The American Museum of Natural History also incorporated mobile technologies into their exhibits. The museum has several fully featured applications, including a designated, self-guided tour application, and other applications that expand upon individual exhibits (American Museum of Natural History, 2013). For example, an application titled *Dinosaurs* was the first official mobile application created by the museum. This application provides an entire database of photos and renderings to provide additional information about the museum's vast dinosaur fossil exhibit, including "interactive data on each photo about where the fossil was found and the palaeontologist who uncovered it" (American Museum of Natural History, 2013).

The Smithsonian National Zoo created a mobile application to enhance visitor experiences, increase food and membership revenue, and support eco-friendly initiatives (Smithsonian, 2013). The application included live web camera feeds of animals, a detailed map, Zoo news, and a section for children's content such as solvable puzzles and animal noise recordings (See Figure 2). Users had to purchase the application for $1.99 USD. It was marketed and promoted through various forms of media such as kiosks, websites, and social media advertisements (Smithsonian, 2013).

The review of the application in August 2013 showed there were about 38,000 downloads and $70,000 USD in gross application revenue (Smithsonian, 2013). Its popularity was attributed to its engaging content, usability, and value - it cost less money than the paper map. The application pushed the Zoo's eco-friendly initiatives since it did

not rely on paper copies. Reviews concluded that the application enhanced the visitor experience at the Zoo.

Figure 2: Screenshot of Smithsonian Zoo Application menu

Another review focused on an application designed for children at the Museum of Industrial Olive Oil Production in Lesbos, Greece. In the application, the user completed a number of ordered tasks associated with the olive oil production process. While the application was too new to have been evaluated at the time of the paper, the research group recommended that a future evaluation should not only concentrate on technical and interactive issues, but also assess the quality of content, amount of related social interaction, and how many people did not have a device capable of using the application (Chatzidimitris, Kavakli, Economou, & Gavalas, 2013).

2.5.1 Evaluating Mobile Learning Technology

Mobile education applications are changing the way museums attempt to educate visitors. Unfortunately, developing methods with which to evaluate these applications is difficult because there are no well-defined mobile application evaluation standards. This issue largely stems from being unable to define or conceptualize mobile learning from the learner's experience (Ally & Traxler, 2009). Most current digital education evaluations utilize some form of focus group, interview, observational data, or questionnaire to determine the educational and entertainment value of the mobile application. However, there are currently no common practices for these evaluations (Ally & Traxler, 2009).

Ally and Traxler attempted to outline qualities of a 'good' mobile technology evaluation. Researchers produced a list of seven attributes, but warned that evaluating

mobile learning is unusually challenging. A ‘good’ evaluation of mobile learning technology should address the following characteristics:

- Rigorous - the conclusions can be trusted and repeated;
- Efficient - the evaluation does not use unnecessary resources;
- Ethical - the appropriate legal forms and protocols are present;
- Proportionate - the evaluation is not more burdensome than the development of the application itself;
- Authentic - obtain the user’s real opinions;
- Appropriate to the target age and their learning ability, and
- Consistent practices used throughout the evaluation (Ally & Traxler, 2009).

The evaluation of these applications is still a new practice with many flaws. Evaluation protocols cannot account for the variability of design and purpose within each individual application, but it is important to begin reviewing the effects of mobile learning due to its future potential as a more widely used teaching tool (Ally & Traxler, 2009).

Vavoula and Sharples (2009) identify six different challenges in evaluating mobile learning: capturing learning context and learning across contexts, whether anything was learned, ethical concerns, mobile technology, seeing the bigger picture, and whether the learning is formal or informal. Many of these challenges are related to learning, whether it is the manner of learning or if learning even occurs. Because learning is different for everyone and cannot be definitively measured, it is difficult to determine whether visitors actually learn more from using mobile applications.

To combat these challenges, Vavoula and Sharples propose a three-tier evaluation plan to help ease the evaluation process. The example application they used was *MyArtSpace*, a mobile application that combines mobile phone and web-based service to support learning between schools and museums (Sharples, Lonsdale, Meek, Rudman, & Vavoula, 2007). Its primary objective was to connect a school museum trip with classroom activities for further study. They hoped to evaluate *MyArtSpace* to determine the amount and quality of learning that students obtained from the application.

The first stage of evaluation was titled the ‘Micro’ stage. This stage examined the individual activities of the technology users and assessed the usability and utility of the educational technology system. In *MyArtSpace*, this included collecting objects through codes, making notes, and taking pictures. The next stage, referred to as the ‘Meso’ stage, examined the learning experience as a whole to identify learning breakthroughs and breakdowns. For students using *MyArtSpace*, this stage included the connection between learning in the museum and the classroom, as well as determining where any

learning activity might be hindered. The final stage was defined as the ‘Macro’ stage. This stage examined the impact of the new technology on established educational and learning practices in institutions. The application used in this study helped to encourage “the appropriation of the new technology by teachers, [and] the emergence of new museum practices in supporting school visits” (Vavoula & Sharples, 2009).

2.5.2 Resistance to Digital Media

The addition of digital devices and media as interactive elements has the potential to greatly enhance the museum experience and foster a deeper understanding of the messages being conveyed. However, some argue that this interactivity is ultimately non-beneficial to the actual understanding of the material at hand. Critics of interactive technology cite a fundamental tenet of museums in the past that an “object speaks for itself” (Fritsch, 2007). This is known as formalism and is based on the idea that every person who views an object sees and subsequently interprets the same messages. By encouraging users to leave their digital mark on an object as explained above, they are able to take away their own meaning (Hawkey 2004). Formalism no longer applies and the museum has less control over what the user takes away from the experience. In this situation, leaving information up to visitor interpretation may negatively impact the learning potential of their museum experience. While users may enjoy the use of digital tools, the museum’s message can be lost in the process. Because there is a fine line between entertainment and the acquisition of factual knowledge, it is important that technologies used to supplement museum exhibits consider what the user takes away from the interactivity and whether it is beneficial or harmful.

Other experts cite that development of these applications is a difficult process that ultimately may not be worth the resources. Some curators describe the process of developing and implementing digital technologies to be problematic since interactions have to be designed to encompass a diverse museum population. They must be accessible to audiences, while tackling obstacles such as age, and difference in interests and opinions. Ultimately this can prove to be far too much effort for a populace who may end up dedicating only a few seconds to each exhibit (Lehn, Hindmarsh, Luff & Heath, 2007).

In response, other studies find that digital technology enhances understanding and interaction with objects. One study at the Austrian Technical Museum, Vienna observed visitors in an exhibition on the history of media that made extensive use of digital technologies in tandem with more classical museum objects. The study showed

that the digitally interpreted exhibit items attracted more people and engaged them longer than the objects with more traditional interpretive text and graphics (Hornecker & Stifler, 2006). Digital objects actively hold a user's attention for longer periods, making it easier to convey the purpose of an exhibition. This creates a more powerful learning environment for visitors (Hornecker & Stifler, 2006).

Critics seem to be in the minority as interactive mobile applications continue to experience increased use in recent years. The potential they offer to enhance museum experiences by providing additional information and interactivity to existing exhibits is enticing. Of over 500 surveyed museums, 43% are currently using some form of mobile technology (Tallon 2013). This is a 10% increase from findings in 2012 (Tallon 2012). An additional 23% of surveyed institutions don't currently have a mobile experience, but plan to launch one to within the next year.

2.6 Mobile technology

As part of the push toward greater interactivity and visitor engagement, many museums are incorporating both fixed and mobile digital technologies in their exhibits and programs. Mobile applications traditionally serve the purpose of supplementing information within the existing exhibits (Hornecker & Stifter 2006). These applications are specifically tailored by the museum in order to provide relevant, factual, and easy to understand information; searching for information online cannot provide the breadth of relevant information offered by a museum application (Hawkey 2004). By providing an entire database of information about specific items at the touch of a finger, such as fossils found in the American Museum of Natural History, users are put in control of obtaining the information they desire (American Museum of Natural History, 2013).

Recently, museums have been offering multimedia tours via provided devices. These proved more effective than audio guides for providing a directed experience for visual and audio learners (Christensen, 2011). Due to the rise in popularity of personal mobile devices, it was a natural step to develop interactive multimedia tours for personal devices. Thus, museums have started to create mobile applications that work on smartphones. This also allows museums to design guides for ranges of people who visit their museum, including frequently visiting members and tourists who are visiting for the first time. Mobile technologies enhance the visitor's experience by expanding on the information that the museum presents in text panels. This creates a more meaningful visit, bolstering the takeaway message the museum hopes to create.

More and more museums are adapting their galleries to include mobile applications, but do they actually help the museum achieve its objectives? A set of visitor surveys and museum guide evaluations done in major museums throughout Europe and the United States in 2010 attempted to answer that question. The study found that almost half of the respondents use audio guides when available at a museum. The most common reason for using one of these guides was that they learned more from the museum visit. A number of respondents also indicated they preferred an audio guide for the entertainment value. This study also found that about 78% of those who preferred guides would rather have one with audio and video content, rather than just audio (Petrie & Tallon, 2010).

Overall the study concluded that the younger visitors prefer multimedia guides with audio and video, compared to an older audience that prefers only audio guides. It also indicated that younger audiences preferred using their own device, while the older audience would rather have a museum provided device (Petrie & Tallon, 2010). At the time of this study only 12% of museum respondents had a smartphone, while a recent study finds that 56% of Americans, 57% of European Union (England, France, Spain, Germany, and Italy) residents, and 84% of Australians now own a smartphone (See Figure 3). This study shows that there is not only a large audience of people who desire mobile applications with both video and audio, but also that the number is predicted to grow as smartphones become more available.

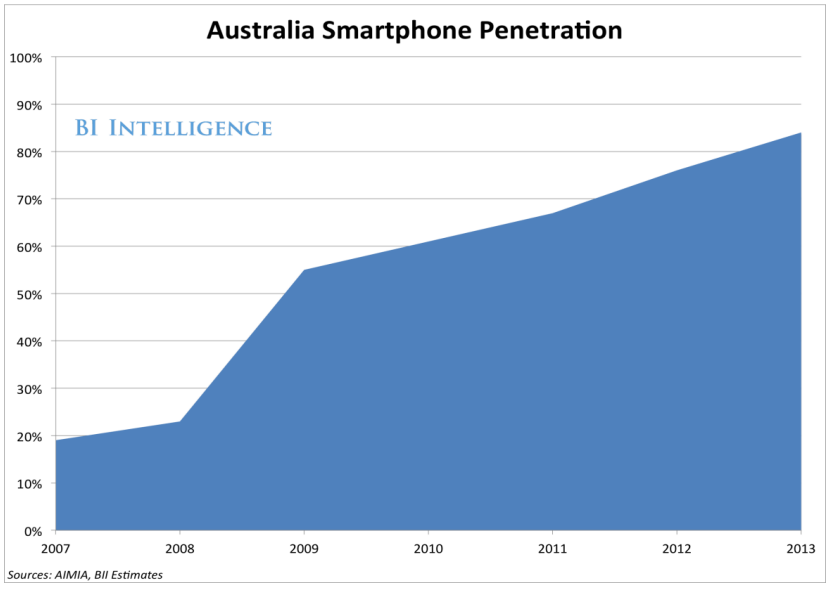

Figure 3: Growth in Australian Smartphone Penetrations (Luger, 2013)

Applications can enhance the visitor and learning experience, but should never completely divert visitor attention from the objects on display. Rather the applications should be designed to provide supplementary material and experiences to increase the

visitor's interest further (Hornecker & Stifter 2006). This is the end goal for exhibit-based mobile applications. Fritsch (2007) claims these applications must be developed so they do not encourage the visitor to completely disregard the exhibit itself and solely focus on the game within the application. If such issues can be avoided, the overall experience of the mobile application can enhance the museum exhibit and provide more knowledge beyond the context that the museum can present on its own.

2.6.1 Children and Mobile Technology

Since modern students are so accustomed to constant media stimulation, education and technology may work well as a means for teaching within museums. Primary school-aged children move from idea to idea very quickly and handheld mobile technology allows them to be involved in "foreground activities" while still connecting to abstract knowledge (Druin, 2009). This creates an environment in which children can observe, collect, and assess their museum journey in a meaningful way. Ultimately this fosters a more memorable experience through the excitement of interaction. Also known as "connection building," interactive elements enable children to imagine things in a broader perspective (Charitonos, Blake, Scanlon, & Jones, 2012).

In an analysis of mobile technology for children, constructivist approaches are highlighted as the most useful educational instructors (Druin, 2009). When children have the chance to explore and build a personal experience, it is much more meaningful. Since research suggests children retain information best that is presented in a short time frame, mobile applications with brief segments stimulate a child's interest. Applications also "excel in contextual learning" (Metcalf & Rodgers, 2010). This allows children to construct a relationship between the mobile content and the physical space of a museum. This multi-platform approach enables "enhanced conceptual retention" (Metcalf & Rodgers, 2010). Digital media, specifically mobile applications, aid children during their visit to the museum. This technology not only allows museums to share more information with visitors, but also creates a connection with a younger audience (Druin, 2009).

2.7 Museum Victoria and *Time Lens*

The Museum Victoria organization has embraced technological advances by creating the digital application *Time Lens Episode I: Treasures and Gems.* The application was created to engage audiences, particularly younger children, with the current pre-existing galleries located in the Melbourne Museum. The museum hoped to

build upon the information shown within these galleries and presents them in an entertaining way to engage younger audiences.

To ensure this application was accomplishing the goals its designers outlined, the museum conducted a formative evaluation that resulted in valuable information regarding user opinion. The review revealed that the application profoundly changed the visitor experience by focusing engagement and attention of visitors (children in particular). The application encouraged visitors to explore new areas of the museum (Museum Victoria, *Time Lens* Formative Evaluation, 2012).

Additionally, the evaluation found that that people would use the application in one of two different ways: either working as a guide to find where to stop in the museum or as a race through the museum to collect all of the achievement-based badges. Children using the application would occasionally compete to operate the device and older children had the tendency to charge on to the next gallery alone, splitting the group. This division negated opportunities for family collaboration and increased learning, as mentioned above. On the other hand, *Time Lens* provided purpose for learning at the Melbourne Museum and created a new experience for visitors, encouraging additional learning from other areas of the museum (Museum Victoria, *Time Lens* Formative Evaluation, 2012).

If the *Time Lens* application does not continuously engage visitors, it will see very little use and be poorly received. If it fails to provide meaningful information to users, it will detract from the overall museum experience, shifting the focus to game achievements rather than learning new information. For this reason, it is imperative that *Time Lens* retains focus on the education of its users and avoids becoming a simple game. Further research will need to be conducted in order to determine how well the application balances the ability to teach a target age group of primary school children while encouraging a positive and entertaining experience.

The length of use of the application, as indicated in the formative evaluation, is between one and a half to two hours long. This is an overall statistic and does not examine time spent in other galleries visitors may encounter on their journey that are not included in the application. The time also does not account for the differential time spent per gallery for groups that do not use the application. Determining the actual amount of time spent on the mobile application in comparison to a regular museum visit must be explored further.

2.7.1 Future Plans

Since the organization hopes to implement a second iteration of the *Time Lens* application at the Melbourne Museum, the application must be reviewed once again in preparation for new planning. This new application will continue the *Time Lens* series, adding to the suite of digital applications offered by Museum Victoria. It will not aim to replace the current version of *Time Lens*, but rather act as a companion application.

Since each gallery in the Melbourne Museum has a unique focus, the application will explore each gallery within the museum as a separate experience. Sectioning off each gallery will benefit the length and content of the application. Once the evaluation has been conducted, the most recent visitor opinions can be used to create an application that will be well received. Our background research will guide us as we conduct the evaluation and begin drafting plans for the new mobile application.

In the past, museums simply contained historical relics in an unchanging, lifeless environment. Due to recent shifts in education and learning styles, modern museums have become an engaging and interactive environment. The rise of digital and mobile technology has aided in creating an exciting atmosphere at museums. Visitors are active in ways they never were before: touching objects, answering questions, and exploring previously unseen exhibits through digital technology outlets.

As mobile technology continues growing, it offers exciting new opportunities for museums. Museum Victoria has embraced changes and advancements, hoping to create a better experience for visitors. Implementing *Time Lens* in the Melbourne Museum was a starting point for the organization. With many changes evolving in museum exhibit design and advances in digital technology, it is the perfect time to begin plans to implement new mobile application with the hope of further increasing visitor participation and engagement.

3. Methodology

The overall goal of this project was to evaluate the effectiveness of the current *Time Lens* application and generate ideas for a new application to be developed in the near future. To accomplish this, we identified four objectives:

- Assessed the best practices in the use and evaluation of digital applications for exhibit interpretation;
- Determined the effectiveness of the *Time Lens* application through evaluation by our peers, museum members, and non-member visiting families;
- Determined the appropriate themes, functionality, and content for the new application through preliminary design development and storyboarding; and
- Recommended how the museum moves forward with the future development of the application.

At the Melbourne Museum, we observed and discussed *Time Lens* with Museum Victoria members and non-member visitors who used the application. We gathered opinions from our WPI student peers who used the application during their first visit to the museum. We conducted this summative evaluation of the application through discussions with members, non-members, and peers to identify certain elements, features, and content that were successful and how negative aspects could be improved in future application design. We used this information to brainstorm ideas for the next mobile application.

Based on feedback from staff members and brainstorming within the group, we moved forward with plans for a new, exciting application. The original *Time Lens* application was generally well received by users and had recently obtained an award from the E-Learning Industry of Victoria (E-Learning Industry of Victoria, 2013). This positive feedback persuaded us to develop design ideas for a new digital application for use at the Melbourne Museum instead of simply updating and improving the original application. After completing a preliminary design and storyboard process, we presented these recommendations to museum staff involved in mobile application production.

3.1 Objective 1: Assessing Best Industry Practices

Our team conducted an extensive review of literature to understand the role that digital and mobile technologies play in developing modern museums. Such technologies influence exhibit interpretation and enhance the visitor experience. We also reviewed literature on other museum application reviews to gain a general sense of how mobile

applications have successfully been adapted to use in cultural institutions. To supplement this research, we tested multiple mobile applications in use at a variety of museums in Australia and elsewhere in the world. Since mobile applications are becoming more common to supplement exhibits, we determined it was important to understand other strategies and ideas in current educational application design (Tallon, 2013).

We selected various museum applications to explore different features to implement or avoid in our application development process. The Taronga Zoo application titled *Monkey Mayhem* set up a zookeeper character who needed the user's help to track and record information about various zoo creatures. We reviewed this application because it was aimed at children audiences and fostered an experience that the child could refer to even after their trip to the zoo. We analysed the application *Museum Hunt* that could be used at many museums to determine the efficacy of a standard template design application. The application incorporated riddles to direct the user to the next objects in museums, which seemed more intuitive than the system used in *Time Lens*.

We also reviewed *Love Lace*, an application created by the Powerhouse Museum in Sydney to accompany their Lace Design Gallery. This application was dissimilar to *Time Lens* because it did not contain any game or challenge, rather just presented the user with a wealth of additional information of excellent quality. However, it was not very engaging or useful for those who did not learn best through reading. The American Museum of Natural History's *Explorer* application used a scavenger hunt system similar to *Time Lens*. The application included a dynamic map and directions to locate every object in the museum. The application delivered content effectively to visitors, and the map was for very useful for way-finding.

3.2 Objective 2: Evaluating the Current *Time Lens* Application

Our team solicited feedback about the current *Time Lens* application in the following key areas of interest: usability, navigation, group dynamics, length, content, challenge, education, enhancement, and entertainment. We also asked users to suggest major changes to help guide modifications for a sequel mobile application. Through observations and discussions with member and non-member families as well as our WPI student peers, we collected various opinions of the application. Observations provided data about the time and order of exhibits visited by groups utilizing *Time Lens*. We used

discussions to obtain opinions about the application's functionality and effectiveness in the categories listed above.

3.2.1 Staff Interviews

We interviewed Museum Victoria staff involved in the development and planning of the original *Time Lens* application to determine the original plans and goals of the application. Our team consulted with our sponsor liaison Carolyn Meehan, Director of Marketing Research and Evaluation, to identify key Museum Victoria staff members involved with the creation of the original *Time Lens*. We talked to staff from Education and Community Programs, the Digital and Emerging Technologies team, and the Audience Insights team.

Staff interviews consisted of an initial proposal of our plans, followed by a guided discussion (See Appendix B for the Staff Interview Guide). We asked a series of questions pertaining to the development of *Time Lens,* previous evaluations done on the application, and developmental plans, if any, for expansion of digital application use at the museum. Specific questions focused on the staff member's observations of *Time Lens* in use throughout the museum and their opinions of mobile technology being used at the Melbourne Museum. Our team also asked staff members about evaluation protocols including sampling strategies and the use of pre-loaded mobile devices. These conversations provided additional background information and personal insight from staff experience with *Time Lens.* From these conversations, we were able to discern how content and functionality were implemented into *Time Lens.* We also gleaned suggestions from staff about previous evaluation techniques and how to facilitate evaluation discussions.

3.2.2 Familiarization with Location and *Time Lens* Application

In order to familiarize ourselves with the venue, we ventured around the Melbourne Museum with a volunteer tour guide. This was the first time we explored the museum. We noted unique features of the museum, as well as what the guide chose to highlight for the audience during the tour.

After touring the museum and traveling through the various galleries, we evaluated *Time Lens* from our own perspective. Each individual in the team travelled the museum while using the application, noting any positive and negative features about the layout, content, and usability of the application. We were also analysing the challenge level of the riddles and whether the content was age appropriate. We then convened as a group to discuss aspects of the application that were effective, as well as those that caused major issues. We found that the positive aspects of *Time Lens* included the

animations and the scavenger hunt system. Negative aspects of the application included the over-simplicity of the riddles and the lack of validation for arriving at the correct object. Since we were unfamiliar with the museum at this point, some members of our group had trouble navigating the venue relying on the map used in *Time Lens*.

Currently, the Museum Victoria advertises a walking tour application and two additional field guide applications in addition to *Time Lens*. Although these applications do not have similar content, we reviewed them on-location to see how they worked. This brief review provided insight about designs used in other Museum Victoria applications. By taking a closer look at the Melbourne Museum and the current state of *Time Lens*, we better understood the application as it was used at the museum.

3.2.3 Developing and Revising Evaluation Protocols

After we toured the Melbourne Museum and tested out *Time Lens*, our team revisited the discussion questions planned for the evaluation. Our travels around in the museum paralleled a visitor's experience and provided us with an understanding of what we should ask during our evaluation. We also referred to the previous formative evaluation where we were provided with a brief summary of visitor opinions about *Time Lens* that we could elaborate on for the purposes of our summative evaluation.

We gained additional insight from literature about mobile application evaluation. Although this is a relatively new process, we attempted to implement Ally and Traxler's (2009) findings in our own discussion. We conducted in person post-discussions immediately to ensure authentic opinions. We also remained consistent in our discussion questions, despite questioning two dissimilar groups.

3.2.4 Implementing the *Time Lens* Evaluation

To evaluate the *Time Lens* application, we collected information through observations and discussions with both member and non-member families that used the application, as well as gaining critical appraisals from our WPI student peers. Observations provided quantitative data about the time and order of exhibits visited by groups utilizing *Time Lens*. Our discussions were structured to obtain visiting families' opinions about the application's functionality and effectiveness.

3.2.4.1 Target Samples

We chose to conduct evaluations on weekends and public holidays because these were periods when member families were most readily available. We selected Monday, 4 November 2013 since many children did not have school due to Melbourne Cup celebrations. Since our peers were not required to work that day, we requested they visit in the afternoon to complete an evaluation of *Time Lens* (See Figure 4).

Evaluation date	# *Of Member families*	# *Of Non-member families*	# *Of WPI peers*
4 November 2013	6	0	18
10 November 2013	4	3	0
Total	10	3	18

Figure 4: Number of Participants in evaluation by category

Since we spent the entire day observing and interviewing member families and student peers, we were not able to recruit non-member visitor families to partake in our evaluation on this day. We additionally scheduled several member families and recruited non-member families with the aid of a table display promoting *Time Lens* on Sunday, 10 November 2013. Participants who agreed to complete our evaluation were assured that their involvement was entirely voluntary and their responses would remain confidential. Only aggregated and/or anonymous answers were reported.

Museum Members

The previous formative evaluation conducted by the museum surveyed sixteen Museum Victoria members, including children within the target age range of six to ten years old. We worked closely with appropriate museum staff to develop a strategy for recruiting more Museum Victoria members interested in assessing *Time Lens.* This entailed emailing members informing them of the evaluation and coordinating discussion times. The sample for our summative evaluation consisted of ten member families with children age six to twelve. We treated each family group as one respondent since the entire group completed discussions.

Non-member families

Additionally, we interviewed three non-member visiting families to gain a wider range of opinions. Since *Time Lens*, like other museums applications, had not yet been widely adopted by general museum visitors, it was difficult to find a large sample of visitors with the application pre-loaded on their mobile devices. To facilitate more responses, a team member was stationed near a *Time Lens* information table in the lobby set up to inform visitors about the application.

We defined a non-member visiting family as any group containing one or more adults with one or more children who appeared to be within the target age range of six to twelve years of age. We attempted to approach every group that fit this description that showed interest in testing *Time Lens*. We anticipated that some families may be interested but were not able or willing to download the application on their personal mobile device. We provided these family groups with an iPod pre-loaded with the application if they agreed to participate in our evaluation.

Peer Groups

To gain a different perspective from visiting families, we solicited the help of our peers consisting of other WPI juniors completing their Interactive Qualifying Project projects in Melbourne. They were all within the age group of 19 to 21 years old. Since most of these students were studying in engineering and technology fields at WPI, we regarded their opinions as a critical appraisal of technological components of the application. The peer groups were more concerned with determining how well *Time Lens* functioned as an application. This varied greatly from visiting families who were more concerned with the experience the application created.

3.2.4.2 Data Collection

Upon their arrival to the museum, members were led to a reserved activity room. We introduced ourselves and briefly discussed the goals and objectives of our project. If necessary, we provided the group with a device that had the application pre-installed and running on the initial screen. Our team instructed families to return to the activity room after completing of the application. After this introduction, we let the member groups into the museum to begin use of the application.

We brought the peer groups to this same activity room to provide them with an introductory explanation. Since we had already informed them about the general overview of our project, we briefly discussed their purpose to provide a critical, technologically focused review of the application. Peers were split into groups of three to five and provided with a single device to share amongst each other.

We recruited non-member visiting families at a *Time Lens* information table set up in the lobby of the museum. If visitors approached the table and showed interest in the application, we asked them to participate in our evaluation. We briefly discussed the goals and objectives of our project, as we had with member families. They were then sent out to explore the museum galleries using *Time Lens*.

We performed observations on the floor the same way for member and non-member visiting families. Once a group was sent off into the museum, a member of our team would discreetly follow and track the movements of the family group from a distance. The observer would note on an observational checklist the time a group spent at each gallery and the order of exhibits visited. If a family appeared to show greater interest in a particular object it was recorded. Likewise, the observer made notes if a family skipped over any objects. We did not observe peer groups as they used the application due to differences in interest between the targeted child age group and the peer's age group.

After completing the application, peers and member families returned to the activity room. Visitors returned to the *Time Lens* display table, but were then directed to the activity room. All groups underwent the same discussion process, albeit with questions ordered and worded slightly differently. We recorded discussions using a digital recording device so we could revisit the conversation later and make additional notes. Additionally, the interviewer took notes throughout the course of the discussion. We divided the discussion questions into subcategories to focus on many parts of the application. This also helped us make sense of the data when we began drawing conclusions from our results.

3.2.4.3 Data Entry and Analysis

After conducting the observations and surveys, we compiled a comprehensive summary of data. This summary served as a reference for designing the new application for the Melbourne Museum. We organized the responses from each group based on the following subcategories: usability, navigation, group dynamics, length, content, challenge, education, enhancement, entertainment, and suggestions for major changes. Each of these categories contained one or two focused questions during the discussions. We classified responses to these questions as positive, negative, or other. This formatting proved very useful for our analysis since we were able to compare responses very easily (See Figure 5).

		Usability		
		Positive	Negative	Other
Group 1		Application worked as it was supposed to for entirety of use	Hard to click areas on the map. Squid was in a different area than other parts of badge.	N/A
Group 2		No major problems. App layout was intuitive.	One of the iPads crashed once, but quickly resolved.	N/A
Group 3		No major issues.	App shut off once after playing a video.	N/A
Group 4		N/A	Confusing when the wrong answer goes gray. A red X would be better. Confusing on how to start the game. The map was a little "rough", didn't show badge areas well.	N/A
Group 5		No technical issues	N/A	N/A
Group 6		No difficulty with interface and no tech issues	N/a	N/A
Group 7		No difficulty with interface and no tech issues. Layout was great!	N/A	N/A
Group 8		Layout worked well for one person.	Didn't realize that the app had sound until 3/4 way through museum. Layout wasn't good for more than one person.	N/A
Group 9		N/A	Time Lens crashed a few times and the directions were a little ambiguous.	N/A
Group 10		No tech issues.	Wanted to be able to download at Melbourne Museum. Kids could cheat too easily.	N/A
Group 11		No tech issues.	App didn't automatically lead to the next gem after completion.	N/A
Group 12		No tech issues. Layout was easy and intuitive.	N/A	N/A
Group 13		No tech issues.	The layout took a little bit to get used to.	N/A

Figure 5: Organized member and non-member family responses

After dividing the data based on positive, negative, and other comments, we began comparing responses from different groups. We highlighted points reiterated by multiple families. We used these comments when we presented our evaluation findings to clearly communicate the feedback we had received. We also generated graphs based on our observational data showing the time spent in each gallery and the total time to complete the application.

3.2.6 Internal Dissemination and Discussion of Evaluation Results

After completing our evaluation, we reviewed our findings and drew conclusions. We highlighted opinions that we found to have significant support within the data. Our team compiled the observational data and compared the critical responses from peers. We reported our findings to various museum staff to gather additional feedback and opinions about how to use our findings to begin plans for the new application. To do this, we facilitated an open discussion with the staff members during our first evaluation presentation.

Our first presentation to select staff involved with the development of *Time Lens* was well received and our team was asked to present the same findings to the Online Planning Group (OPG), a team within the museum that decides upon future digital museum projects. This presentation was more directed than the previous. We presented our findings then addressed questions and comments from the OPG staff. They were extremely interested in the information and commented on the importance of our findings in connection with the future of mobile applications used by Museum Victoria.

3.3 Objective 3: Developing Ideas for a New Melbourne Museum Application

Building on the data and opinions gathered during the implementation of previous objectives, we determined the best course of action for developing a new application for use at the Melbourne Museum. After revisiting the subcategories used during the evaluation and analysis, we determined what components our application would need to address any particular issues that might arise. Our team developed overall goals for the application as well as themes to be used throughout. We discussed additional features and interface components as a group. One member of the group noted ideas as they were presented within the group. When we had compiled a comprehensive list of ideas, we systematically reviewed the trade-offs and benefits of selecting one particular feature over another.

Once we agreed on a concept for the new mobile application, our team began selecting user stories, content, and narratives that needed to be storyboarded. The team

drafted brief textual elements and sketches to explain the intended purposes and outcomes of content. Our team worked together to critique, analyse, and compound each other's ideas into a cohesive plan. Eventually, we brought all the storyboards together to create an outline of the application. This represented our plan for future development.

While completing the design process, we discussed our plans with four Museum Victoria staff members who would help implement our designs. We reviewed our findings from our evaluation and presented them with our plans for the new application. We considered their opinions and suggestions to bolster our ideas. We asked them to be critical of our designs and share their desires for the application to ensure staff would be satisfied with the outcome.

3.3.1 Storyboarding and Additional Content

Storyboarding is a crucial step in creating a clear and cohesive piece of software. A storyboard is a graphical description of a narrative or software that is shorter than the final product. Truong and Hayes (2006) found that most successful storyboards contain 5 important attributes: detail, text, humans and emotions, frames, and portrayal of time. There must be a certain level of detail in a storyboard for the group to better understand what objects and actors are in each frame. An example of a storyboard we developed for our new application is shown in Figure 6.

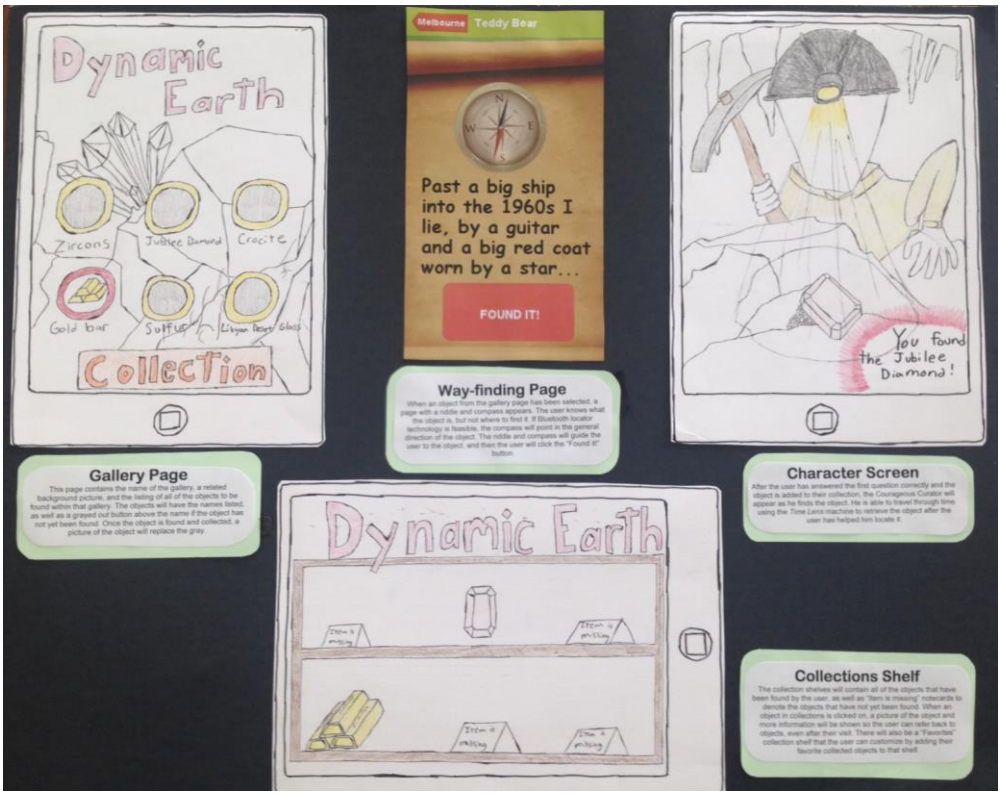

Figure 6: Example of a preliminary concept storyboard

Although not present in every storyboard, text is helpful to describe a frame in more detail. Text can be displayed as labels, thought clouds, and speech bubbles. Digital application storyboards will often include human users and their emotions in the storyboard to show how a scenario should affect the user.

Storyboards are created through a multistep process involving many people. Before the storyboard process can begin, designers must first fully understand the targeted audience. The design team can deliver material effectively only when they understand the user's technical affinity and response to certain content (Truong & Hayes, 2006). Once there is an understanding of the user, the team begins brainstorming. This process typically involves all team members to share, refine, and filter ideas. Truong and Hayes claimed brainstorming required "all experts … to be as open and creative as possible" (Truong & Hayes, 2006).

The goal of brainstorming is to present a generalized story and appearance of the application. Once the overall idea has been chosen, the design team must begin constructing the actual storyboard. These displays should cover multiple sections of the application, making sure there are no more than five frames relating to each section. The team writes short sentences to describe each frame and draws sketches corresponding to each text statement (Truong & Hayes, 2006). The last step in the storyboard process is to test and continue the storyboard. Modification may be necessary based on early feedback.

For our storyboards, we used a combination of sketches and digitally rendered screenshots using FluidUI Prototyping Software. We took photos of objects we used for sample content, wrote questions and text blurbs to accompany the sketches and selected objects, and worked to make sure the questions and vocabulary were appropriate for our targeted audience of children aged eight to twelve. We were able to compare opinions from our evaluation to determine the appropriate challenge level for users. After forming early design plans and reviewing them with involved staff, our team began discussing more components of the application. We entered another team brainstorming process to decide on the interface and additional features. We detailed these plans with suggestions and reasoning for each feature. When all of these elements were completed, we have a physical presentation of our design plans for the new application.

3.4 Objective 4: Recommendations for Development

Once we completed the brainstorming, designing, and storyboarding for the new application, we outlined additional suggestions for the museum regarding digital and mobile technologies. Many of our evaluation findings can be applied to the Museum Victoria website or other museum applications. Final overarching recommendations discussed marketing strategies, general application enhancement feedback, mobile device usage, and plans for a built-in survey in the new application. Our review of *Time Lens* provided specific feedback useful for designing a new application, but also insight about how digital applications can enhance and expand the museum experience.

4. Findings

The mobile application *Time Lens Episode I: Treasures and Gems* was designed by Museum Victoria to appeal to families with small children visiting the Melbourne Museum. With the use of animations, riddles, and badges, *Time Lens* attempts to craft a museum experience that children between the ages of six and ten can enjoy. Through our study of museum members, visitors, and staff, we examined how effectively the application achieved this goal. Our evaluation provided insight into how *Time Lens* changed the museum visit for member and non-member visiting family groups. These results formed the basis for our recommendations about the development of a new application.

Museum members and peers arrived at scheduled times to complete the evaluation discussion. Non-member visiting families were recruited at a *Time Lens* table set up in the main foyer of the museum. Observations were conducted the same way for both members and non-member visiting families. Once each group had finished using the application in the galleries, we interviewed the adult members following the protocols described above but with a slight difference in questions for member and non-member groups. This summative evaluation of *Time Lens*, in addition to a review of other museum applications, staff interviews, and results from the previous formative evaluation enabled us to better understand the context of these opinions and helped prepare us for designing the next mobile application.

The findings were structured into different sections for each different task. The smaller task findings are mentioned first. The smaller task findings include the results of reviewing other mobile applications to gain a greater sense of other institutions' strategies and the findings from our interview with Melbourne Museum staff who had been involved with the design, development and marketing of *Time Lens*. Also included in these smaller findings is a summary of the formative evaluation, which the Melbourne Museum had completed before the start of the project.

These 'smaller' findings are followed by the larger findings of the summative evaluation. This summative evaluation is split into two sections: family groups and peers. Within each of these two sections, there are subsections corresponding to each category of discussion. Ultimately, these four types of findings enabled us to better understand opinions about the application in order to prepare us for designing the next mobile application. The findings section continues with our recommendations for the design of a new application for the Melbourne Museum. This final section is separated

by the same discussion categories as those of the summative evaluation, and within each category there are both the group's suggestions and our reasoning behind them. Finally, the section concludes with our secondary staff interviews, where the staff critiqued our recommendations for the new application.

4.1 Review of Other Applications

After critically reviewing other applications, we implemented some strategies and approaches we found effective in our design recommendations. From the Torango Zoo's *Monkey Mayhem* application, we particularly liked the streamlined click-through introduction process. It introduced the character and provided simple directions for application use. The application also encouraged family-centred learning since parents would have to help younger children navigate the museum to find specific zoo exhibits. Parents needed to complete the application with the child, helping them take pictures and read information sections.

In the generalized application *Museum Hunt* that included a variety of museum locations, we enjoyed the game-like style of puzzles and riddles. The application used a treasure hunt to connect object clues that hinted at where the object was, rather than what the object was. This encouraged the user to find the object, and inhibited the user from progressing in the application unless they had physically seen the object. This removed any temptation to cheat since the user could not make guesses about the object. While there was educational content, the challenge and rewards presented added a greater entertainment value.

We also reviewed the *Love Lace* application, developed to complement the Lace Design gallery at the Powerhouse Museum in Sydney. This application included images, object dimensions, material specifications, and quotes from designer interviews for lace featured in the gallery. Although it was geared towards adult audiences, it gave us ideas on how to incorporate more information and content into the application. We used this as a model for an application that would not entertain children since it was so heavy with information and lacked engaging or interactive elements.

We modelled our plans for a zoom-capable, interactive map from the one used in the *Explorer* application from the American Museum of Natural History. This application also had big menu buttons for ease of use, and offered interactive tours of parts of the museum. The instructions were intuitive and easy to understand, which helped improve the overall functionality of the application.

To gain a more rounded view of the spectrum of mobile applications beyond the four that we reviewed in person, we obtained scholarly reviews of two other applications. From the ThIATRO application evaluation conducted in a classroom setting, we saw that the quality of the graphics and speed of the application were important to the young users, so more emphasis could be placed on those aspects when designing our new application (Froschauer, Merkl, Arends, & Goldfarb, 2013). The application was similar to *Time Lens* in that it was aimed at a younger age group. Users were required to learn content before advancing in the application, which made it a good comparative application.

The application was also designed to be more open-ended rather than didactic. It set up tasks for users to find certain characteristics of artwork (e.g. use of light contrasts) in each level, and a set number of paintings within the virtual gallery that had this characteristic (Froschauer et al., 2013). ThIATRO did not lead the users step-by-step through the application in a didactic fashion, but rather set the task and allowed the user to decide how they wanted to complete it. Evaluations showed higher interest levels in the artwork presented in than application versus the control group who did not use the application. From these findings, we can conclude that it was successful in engaging users.

The Smithsonian Zoo application review described an application that was designed for both on-site and off-site visitors. With the live web cameras of animals, they were able to reach off-site visitors by offering a chance to immerse themselves in the zoo experience without physically being there (Smithsonian, 2013). The daily activities option in the application gave on-site visitors an opportunity to interact and engage more with the zoo exhibits by notifying them about other zoo activities. This children's menu within the application appeared suitable for a wide range of ages. The 'Zoo-ify yourself' character creation option caters to the younger children with make-believe play, while the puzzles and movies are more suitable for the older children who crave more concrete information and set tasks.

4.2 Staff Interviews

In order to further understand the goals and decisions behind the development of the first *Time Lens* application, we conducted interviews with six Museum Victoria staff. We chose staff members representing a wide range of positions and perspectives including curators, marketing personnel, and conceptual designers involved in the creation of *Time Lens*.

The overall goal during the original development was to create an application that successfully led the user around the museum to selected objects, specifically ones that were often neglected by the average visitor. Interviewees stressed that the element of surprise was an important factor and that the application was designed to show off 'wacky and wonderful' museum objects. In addition to leading visitors through various galleries, the application was designed to provide a learning experience that would appeal to a younger audience that is not always interested in reading standard interpretive text and graphic panels.

With regard to future modifications in subsequent applications, museum staff expressed interest in improved way-finding capabilities. In order to prevent aimless or undirected wandering around the museum, staff believed users need more direct hints about where to go rather than just telling users what they needed to locate. Many staff members thought the map was poorly designed and therefore useless. There was little detail and no way to use the application to navigate from one gallery to another. The map simply provided a basic outline of the museum with pushpins in featured exhibits (See Figure 7).

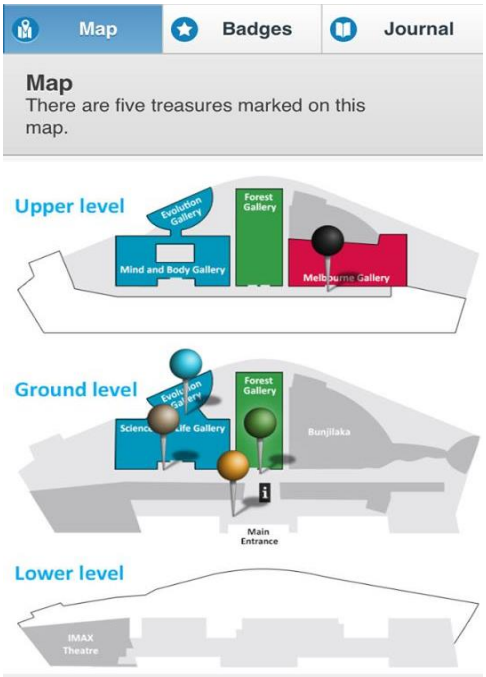

Figure 7: Screenshot of map used in *Time Lens Episode I: Treasures and Gems*

Some staff discussed the option of using Bluetooth technology for location purposes. This technology could also confirm that the application user had arrived at the correct object. This process would involve placing a Bluetooth transmitter near every featured object, enabling the application to check that a signal is being received. When the user came near the object, the Bluetooth would validate the location to ensure the

user had arrived at the correct object. This method would encourage users to travel around the museum and locate hidden objects, rather than guessing the answers prior to even locating the object, which was a problem with the original application.

Staff members also expressed concerns about the lack of a prominent and coherent theme in *Time Lens*. While it was meant to have a 'Steampunk[4] design' based on a contraption called the Fabulous Confabulator that had been previously housed at the museum, the staff felt that this aspect had been missed completely. The application was meant to feature objects that would come alive to users through the machine that the Curious Curator created to resemble the Confabulator (Figure 8). However, this proved very difficult to develop and was only represented by a three-dimensional animated machine featured at the beginning of the information clips. The connection between the Curious Curator and this contraption was not evident beyond the introduction.

Figure 8: The Curious Curator working on the Fabulous Confabulator in *Time Lens*

This caused the theme to appear bland, ill defined, and obscure from the visitor's perspective. The application did not explain or even introduce the purpose of the objects selected for the application. Since the Confabulator was misrepresented, the objects seemed random and disconnected from any particular storyline. They were simply

[4] Steampunk is a genre of science fiction that typically features steam-powered machinery rather than advanced technology. Characters of this genre are typically known for outrageous costumes involving steam-powered technology. (Oxford University Press, 2013)

random objects scattered throughout the galleries and this failed to create a structured, meaningful experience.

Some staff members also questioned whether the future of *Time Lens* was even in mobile application development. Designing the scavenger hunt as a web application could cut costs and development time. Instead of requiring a download, this would allow people to access the application via a web address. With a working Internet connection, there would be little difference between an application designed for the web and a purpose-built application. Instead of designing the application for multiple operating systems, a web application could run on any mobile device. Unfortunately, this method requires a constant and fast Internet connection, and the museum's public wireless Internet does not have these capabilities. Because of technological and networking constraints, it is more efficient in terms of development resources to develop *Time Lens* as an application to download on mobile devices. This was an overall conclusion drawn from staff members who offered broader opinions about mobile technology in Museum Victoria and museums in general.

4.3 Formative Evaluation

Prior to our summative evaluation of *Time Lens,* a formative evaluation was conducted to understand the benefits and difficulties visitors encountered using the application in the museum. This formative evaluation was conducted with sixteen member families including children, who tested the application and reviewed what they liked and disliked about *Time Lens* with Marketing Research and Evaluation staff (Museum Victoria, 2012).

These families enjoyed the animations and the application's ability to provide a new perspective to their visit of museum. They disliked the lack of intuitive instructions and felt that the questions within the application could be answered without being near the exhibit. The ability to answer questions from anywhere reduced the incentive for families to traverse the museum and locate each object.

In general, the families recommended that the application include multiple difficulty levels and that the Curious Curator character have a more prominent presence throughout the application (See Figure 9 and Figure 10). The character was well liked when she did appear, but her lack of involvement with the objects caused users to question her purpose. Multiple difficulty levels could satisfy a greater range of children, addressing concerns of parents who felt the application either too easy or too challenging.

Figure 9: Curious Curator character presented in introduction

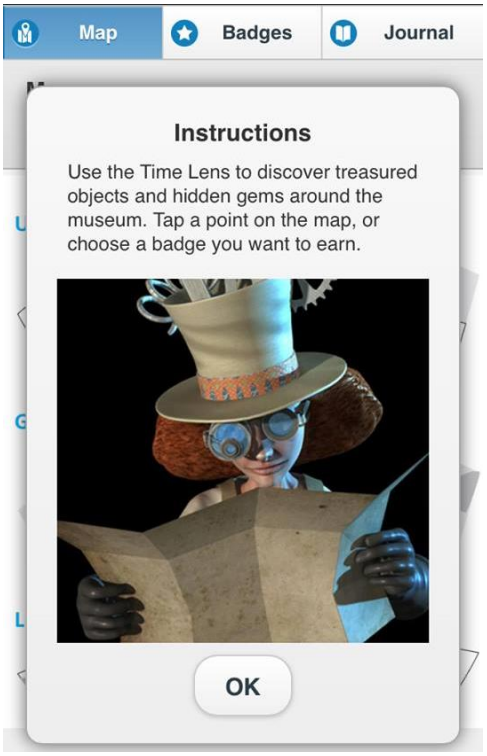

Figure 10: Instructions banner featuring the Curious Curator

The formative evaluation was used to assess the effectiveness of *Time Lens*, but the museum did not use this feedback to modify the original application in any major ways. Our team used the findings from the formative evaluation as a guide to draft our own discussion guide, allowing us to develop categories of interests and questions for

the summative evaluation. It also shaped some of our initial thoughts and plans for the revised application. The findings from our summative evaluation corroborated with some of those from the formative evaluation, but we still gleaned useful information from its results.

4.4 Summative Evaluation Findings

The summative evaluation our team conducted focused on member and non-member visiting families and WPI student peer groups to collect feedback about the *Time Lens* application, as described in the Methodology. Data gathered from observations included the path visiting groups took around the museum, time spent in each gallery, and the total time taken to complete the application. However, some observational data was missing if the observing team member was unable to find the family for a period of time, or where time recordings were not accurate due to certain groups' erratic movements through the museum.

We enlisted the help of our peers to obtain a more technical and functional review of *Time Lens.* Peers were separated into groups with one device. Because of our focus on family group dynamics, it was not necessary for team members to gather observation data on peer groups. We were also able to recruit visitor families to participate in our evaluation. Visitor families approached a table stationed in the lobby advertising *Time Lens* where we had strategically placed a team member to recruit them. There were groups who returned to this station to collect physical badges after completing *Time Lens,* but our team could not observe these families. In this case, they were simply asked to participate in a brief post-discussion and provide a few details about the length of time and order of exhibits visited while using the application to fill in some information that would have been collected during observation.

We asked questions from each defined subcategory for member families, non-member families, and peer groups. The discussions with our peer group varied from visiting family discussions since questions focused more on the technical elements of the application. We presented the initial findings from our evaluation in an open discussion with museum staff directly involved with *Time Lens* on Tuesday, 19 November 2013 and on Wednesday, 27 November 2013 with Museum Victoria's Online Planning Group, which oversees most digital technology used within the museum network. The smaller group of *Time Lens*-specific staff was most interested in the overall family reviews of the application, as well as the perceived lack of marketing that was mentioned by a few groups. The larger Online Planning Group was also interested in the

marketing comments and overall reviews, but looked at the wider implication outside of *Time Lens* and how to improve promotion of any new application within the museum.

Our team found that for many groups *Time Lens* not only entertained families, but also fundamentally changed how they toured the museum. When given control of *Time Lens* and use of a mobile device, children took charge of the museum visit in a way that was fun and exciting for them. Touring the museum became a child-led activity rather than parent-led activity. This shift in roles made museum visits considerably shorter and more tailored to the needs and interests of the children. Many of the parents wanted a more inclusive experience of each gallery and wished that there were more objects included in the application to cover more content in the museum.

One major issue of the application was that the scavenger hunt could be solved without finding or seeing the featured objects, and it was nearly unanimously agreed that the riddles were too easy. This facilitated cheating and curtailed the length of time spent using the application. Although *Time Lens* encouraged children to search for interesting objects around the museum, the application lacked a user-friendly interface and was poorly designed for navigation. These issues discouraged users from searching for objects around the museum.

Regardless of its faults, the application was deemed successful for entertaining and encouraging education of families with young children. Indeed, the first iteration of *Time Lens* received one of the 2013 eLearning Excellence Awards from the E-Learning Industry Association of Victoria. This validates that the final product was overall well received by visitors and other critics. Some limitations and shortcomings were identified, but users and staff alike generally regarded it as successful.

4.4.1 Member and Non-member Visitor Family Responses

For this portion of our evaluation, we focused on Museum Victoria member families and non-member visiting families. During the post-discussion, we solicited feedback in the following key areas of interest: usability, navigation, group dynamics, length, content, challenge, education, enhancement, entertainment, and suggestions for major changes.

Usability

Overall, families did not have any major problems with the usability of *Time Lens*. Most did not experience technical issues, although three of thirteen (23%) families reported that the application crashed. There were mixed opinions on how intuitive the layout of *Time Lens* was. Upon arrival, families were simply briefed about the project and

the purpose of the evaluation. They were given the device with *Time Lens* pre-loaded and prompted to begin. Some users were able to quickly understand how to start the application, while others commented that the layout took a while to understand.

Navigation

Families who frequented the museum had little difficulty with navigation. Some relied on the map within the application to choose their next destination or to visualize where they were in relation to other galleries, while others used the list of badges to establish their destinations. Most families travelled in a location-based order, selecting whichever gallery was closest to their current location. Groups who chose not to use the map claimed it was small and hard to read since there was no zoom option. Some non-member families who were completely unfamiliar with the museum said the map did not provide enough guidance, even causing one group to ask the museum staff for directions.

Group Dynamics

We observed a wide range of interactions within groups. One of our key concerns was how families with multiple children might deal with having only one device per group. Disagreements among siblings were few and far between, and most arguments were insignificant and easily resolved. Despite the occurrence of a few minor disruptions, the majority of families did not experience sharing conflicts. In most families, parental control of the device totally alleviated disputes.

From discussions, we gathered that parents typically lead museum visits for family groups. The adults in the family group set the pace and choose the order of galleries visited, leaving children to trail behind. The use of *Time Lens* created an opportunity for a child-driven visit, even for those who did not have the device totally in their control. This encouraged children to assume a leadership role in directing path the family took throughout the museum, or at least provided them the illusion that they were controlling the visit. In comparison, multiple parents wished they were able to see more from each exhibit, but felt obliged to follow their children's path. Many did not see as much as they would during a regular museum visit, but felt that using the application gave them a unique experience that was not necessarily worse but just different from what they were used to.

Length

Families agreed that the total length of *Time Lens* was appropriate to satisfy a child's interest level. Between the ten member and three non-member groups for which we collected data, the average time spent using the application was 52:55 minutes (See Figure 11). Certain galleries engaged families longer than others. This occurred because of varying interests in exhibit subject matter and the difficulty of finding objects within each exhibit (See Figure 12). Families that visited the museum often, most notably Museum Victoria members, enjoyed that the application could function as a short, directed visit. Others felt as if the application was useful as a child-friendly part of a longer, more expansive visit.

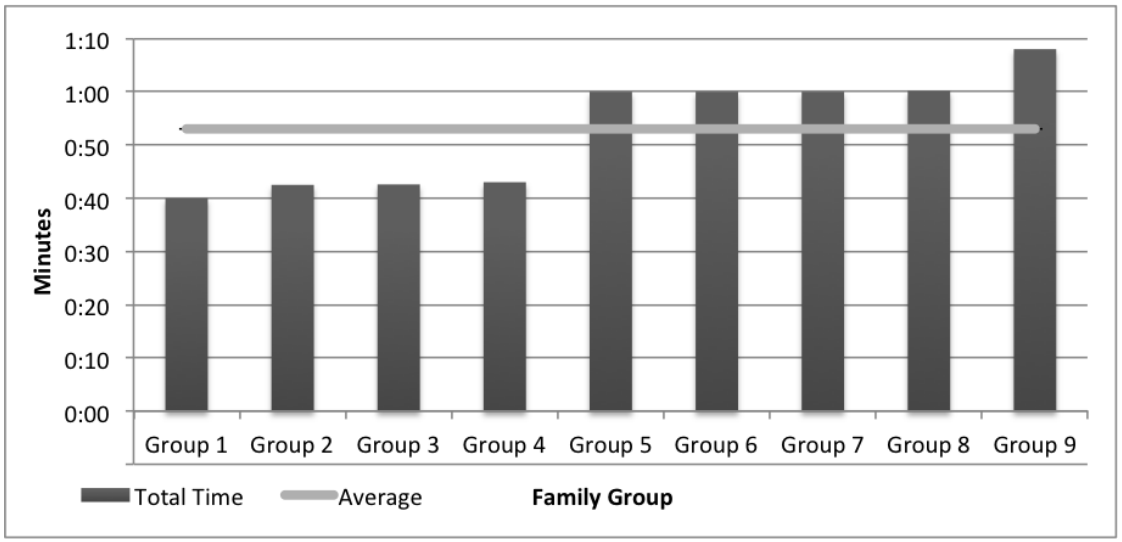

Figure 11: Total Time Spent Using Application (n=10)

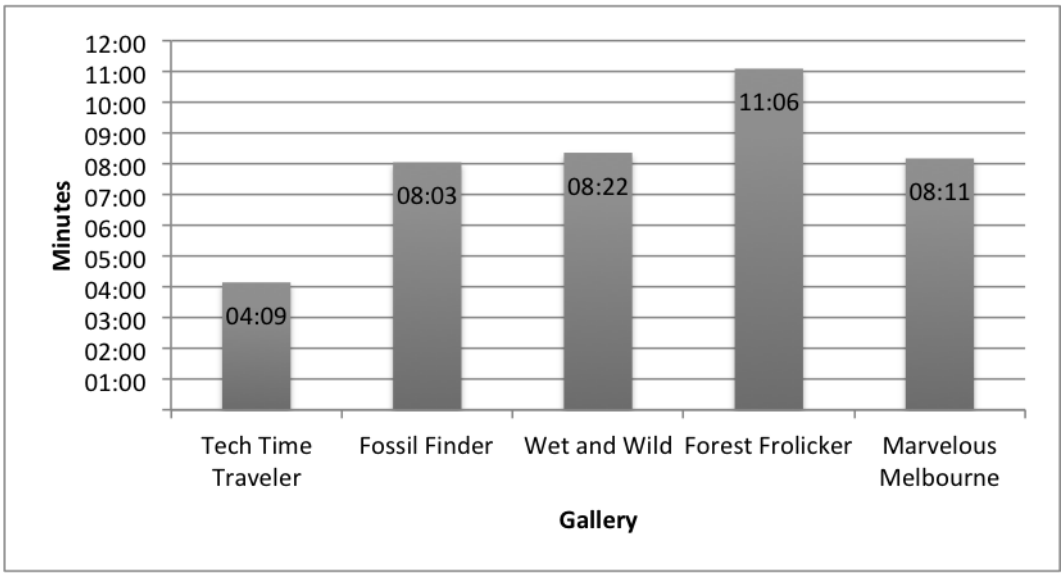

Figure 12: Average Time Spent in Each Gallery

Content

The participating families found the content within the application to be educational and encouraged children to search through the museum for more information. Many desired additional content from the application. Suggestions for how to accomplish this varied from adding more content from each individual gallery to adding more badges and rewards for completing additional challenges.

Challenge

The families had mixed opinions about the challenge provided by the application. The majority of the parents agreed that the riddles posed little challenge, especially for children eight years or older. For younger children, parents expressed satisfaction with the difficulty level. Problems occurred when groups included children of different ages. In these cases, younger siblings were often content with the difficulty of the application while the older children grew bored easily and did not participate fully.

Education

Almost all families felt positively about the educational content of the application, stating that either the parents or the children had learned something new that they had not known previously about a museum object featured in the application. Families also enjoyed that children were encouraged to read object labels while completing a challenge within the application, allowing them to absorb more information.

Entertainment

The families believed that the quality of the animations used in *Time Lens* was excellent. Despite this, some felt that the animations were too long and lacked sufficient engaging information to hold the child's attention. This resulted in some groups or individuals skipping the animations altogether. When asked about the Curious Curator character, many had to be prompted to remember whom she was, since they had glossed over the introduction, which is the only time she is prominently featured. Those who could recall the Curious Curator character liked her, though they thought she should be more present within the rest of the application.

Enhancement

Time Lens successfully created a unique museum visit compared to a traditional guided tour of the galleries. It provided families with a goal and objective to complete

during their visit. Along their journey, many member families discovered new objects they had never encountered at the museum before, showing the application's ability to promote hidden or less popular objects across the galleries. Despite positive feedback, visiting families were hesitant to say outright that the application positively enhanced their museum visit, instead claiming it created a unique experience.

Suggested Changes

At the end of the evaluation interview, we asked each group what changes they would recommend for *Time Lens*. Several suggested multiple difficulty levels to accommodate those who felt the current challenge level in the application did not appeal to a wide range of ages. Several families wanted a map that was more detailed and had zoom capabilities so those unfamiliar with the museum could navigate with ease. Another popular suggestion was that the application should be able to validate that a visitor had arrived at the correct exhibit. This would eliminate cheating and could be accomplished through the use of QR codes, wireless Internet triangulation, or taking pictures to assure they were at the exhibit. Most requested more badges in each gallery or a greater number of featured galleries to encompass more of the museum.

4.4.2 Peer Responses

While evaluating WPI peer groups, we used similar discussion questions as for the member and non-member families. Our discussions focused on the following key areas of interest: usability, navigation, length, content, challenge, education, enhancement, entertainment, and suggestions for major changes. We omitted questions about group dynamic for peer groups.

Usability

The eighteen individual members of our WPI peer group who tested *Time Lens* all responded negatively regarding its usability. They felt the directions, layout, and reactivity (i.e., speed of response) of the application was inferior compared with other applications they had used. Users had problems navigating the layout and found that the buttons on the application were difficult to click.

Navigation

Our peers, unfamiliar with the museum, had difficulty navigating through the venue. They disliked the open-endedness of the scavenger hunt and desired a more

guided structure from the application. During discussions, many suggested having the option of a guided tour of the Melbourne Museum included in *Time Lens* to correct this issue. As first-time visitors with no prior knowledge of the content or layout of the museum, our peers found the map to have limited value.

Length

Our peers were positive about the length of the application. They believed lengthening the application would not result in a loss of interest as long as there were more badges or content within each gallery to continuously engage children.

Content

Our peers felt that the content fit the targeted age group (six to twelve years old). Many thought that the wording in the riddles was age appropriate. However, all peer groups criticized the rhyming, saying that it made the riddles much too easy to answer.

Challenge

Our peers were very negative about the challenge level of the rhyming riddles. They felt that some of the other questions within the application were age appropriate, but that there was little to no difficulty in the rhyming questions. They felt this issue encouraged children to disengage from the experience and guess at answers.

Education

Our peers did not unanimously praise the educational content. They felt the content of the application did not have much educational value. Several commented that the application did guide users to chosen objects, but did not provide more information. They felt that *Time Lens* distracted them from viewing any content that was not featured in the application.

Entertainment

Our peers were generally positive about the entertainment of *Time Lens*, commenting that the animations were age-appropriate and would be enjoyable for children. They felt the application would add fun for children visiting the museum.

Enhancement

Our peers agreed that the application engaged and incentivised children to search around the museum, resulting in new discoveries.

Suggested Changes

Our peers varied in their suggestions. Like the parents, many of them suggested that the application use some sensor or scanner that could recognize the user had arrived at the correct exhibit. Similarly, they desired a more detailed map. Most wanted a more guided structure, such as having the badges in a particular order, or having a designated starting point. Since our peers had never toured the museum before, their opinions varied substantially from families who had frequented the museum multiple times.

4.5 Design Suggestions for a New Application

Our team decided to continue with the *Time Lens* brand so that it could become a recognizable part of the Melbourne Museum. By creating a bright, exciting, and streamlined application we hope to appeal to the age group that was generally bored and unchallenged by the original *Time Lens.* In doing so, we hope to attract and excite more child audiences. Various suggestions and reasoning have been outlined to make recommendations to designers and programmers who will create *Time Lens* in the near future.

Theme

Suggestions

We suggest that the new application, titled *Time Lens Episode II: The Curator's Collection*, be an adventure where users help a curator go back in time and find objects to display in the user's personal exhibit. The main character would be the Courageous Curator (See Figure 13), a daring treasure hunter that would pay homage to classic adventure characters featured in popular books and films.

Future iterations of *Time Lens* could contain new curators as main characters as well, creating a whole family of curators. If the museum chooses to continue creating applications in this series, this would allow for visitors to see a whole cast of characters. This is useful for branding and marketing purposes. The application itself might contain a vibrant, tropical-themed colour scheme that is based on the palette that distinguishes Museum Victoria and its multiple locations (See Figure 14).

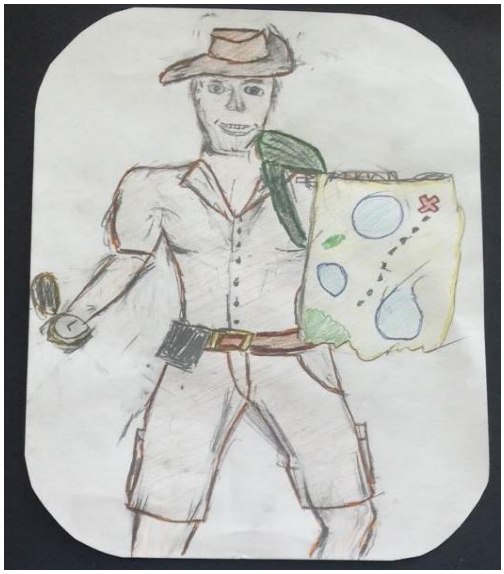

Figure 13: Preliminary sketch of the Courageous Curator

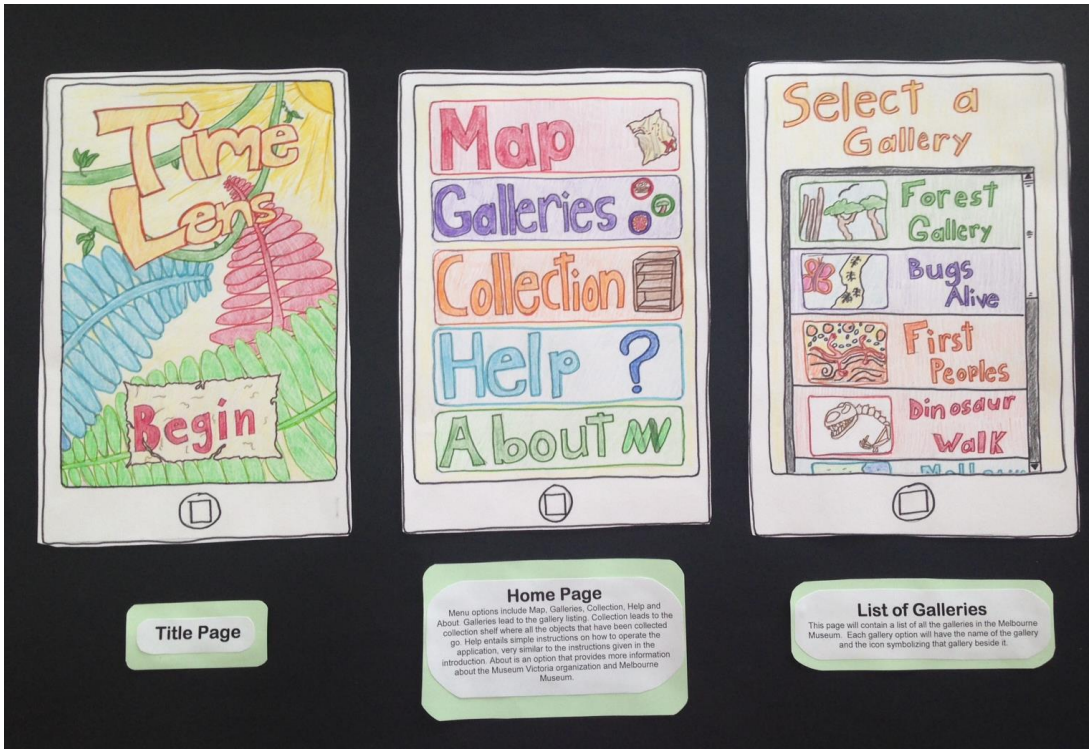

Figure 14: Sketches of introduction screen, home page, and gallery list page

Reasoning

Our team wanted to give *Time Lens* an entirely new feel that has a simpler, more sustainable narrative. Users will embark on an adventure that gives meaning to their visit beyond learning about objects. Since they will have to locate particular objects, application users will be exploring around examining the museum in their travels rather than being completely absorbed by images on the screen of their mobile device. A memorable and entertaining main character will help engage audiences. We decided that a bright, complementary colour scheme would also attract visitors.

Since we want *Time Lens* to be a continuing series, we determined the main character should be a curator. This way he or she can have his or her own persona, but still connect to the previous main character, the Curious Curator. This prevents the new application from seeming either too similar or different from the original. We hope this may eventually lead to a family of curator characters that can be used in marketing. Each of these characters would have a different name and personality, which connects with the theme of the application in which they appear. When these characters are brought to life and placed in the context of an application, they can appeal to various audiences.

Narrative

Suggestions

We suggest that the storyline be sustained throughout the entire use of the application. The user is introduced to the Courageous Curator as a two-dimensional sketched figure during the introduction of the application. Through screen-by-screen instructions, the curator would briefly describe his mission and simple instructions on how to use the application (See Figure 15). He would give tips and comments throughout the application with object-relevant stills and speech bubbles. He would also give a brief 'outro' when the user finishes the application. To facilitate the exploration aspect of the application, the curator would upgrade the *Time Lens* device to send himself back to the era where the object he is searching for originates. His mission, and therefore the user's mission, would be to collect enough objects through his travels to create a new museum collection (See Figure 16).

Figure 15: Beginning screen of new application and Courageous Curator introduction

Figure 16: Courageous Curator in action

Reasoning

Through our observations we found that that the storyline was often overlooked or even ignored by users in the original *Time Lens* application. Because stories help to enhance user experiences by giving meaning to the objectives, we felt it was important to give users a brief plot that was easy to digest and required little attention to follow. Due to the cost and skill required to create three-dimensional animation and the large data sizes of animations, we decided that the character should be displayed in two-dimensional stills, allowing for more versatility in his actions. We want the character to be present as the user finds an object, creating the feeling that the curator is going through the adventure with the user, instead of just sending them to fend for themselves. The storyline is set up so that there is a reason for gathering objects, without the use of a long, complicated narrative that could confuse users.

Objects, Questions, and Difficulty

Suggestions

This new application would contain questions and riddles relating to each object (See Figure 17). We seek to highlight the wacky and wonderful objects that may not typically attract visitor attention. When a user selects an object within a gallery, a compass and riddle would appear. This riddle is designed so that it gives clues to locate the object, while the compass uses Bluetooth signals to point the user in the general direction of the object (See Figure 18). The user presses a button at the bottom of the screen to signify that they have located the object they have been searching for. The user would then be asked a short question that requires you to actually view the object,

ensuring that the player is at the correct location and cutting down on the temptation to cheat (See Figure 19). Two optional, consecutive questions will be asked after the first is completed. The second question would be based on information pertaining to the object provided on the information panel, while the third would necessitate deeper interpretation of the object, use of outside information obtained from school, or information present in surrounding exhibits relating to the featured object.

Figure 17: Object selection from Dynamic Earth gallery page

Figure 18: Digital prototype of riddle page with Bluetooth-enabled compass

Figure 19: Courageous Curator discovering an object

Reasoning

Our team decided to incorporate a system that would make objects relatively easy to find. The main goal of this application is not to challenge user's ability to navigate the museum, but rather guide them on an adventure throughout the various galleries. We wanted to highlight oddball objects at the museum because this was an original goal of *Time Lens* and we agreed it was good to draw people away from the oft-visited and well-known exhibits at the forefront of the galleries.

Our team decided it would be best to implement multiple, increasingly difficult questions to cater to family groups. Since children of different ages may be utilizing the same device, it is hard to segregate the levels as an option upon starting the application, so we agreed that all questions ranging from beginner to expert should continue sequentially in the application. This also encourages intercommunication and community learning among family groups where the child controlling the device may ask the parents for helping answering a more challenging question.

Collections

Suggestions

The Courageous Curator would collect objects as the user discovers them at the museum. These objects would be viewable in a collection page that contains multiple shelves. Users would receive these objects in their collection after finding the objects in

the museum and answering their respective first level question (See Figure 20). Intermediate and expert questions help progress the player towards a Silver or Gold Museum Medal for their entire collection.

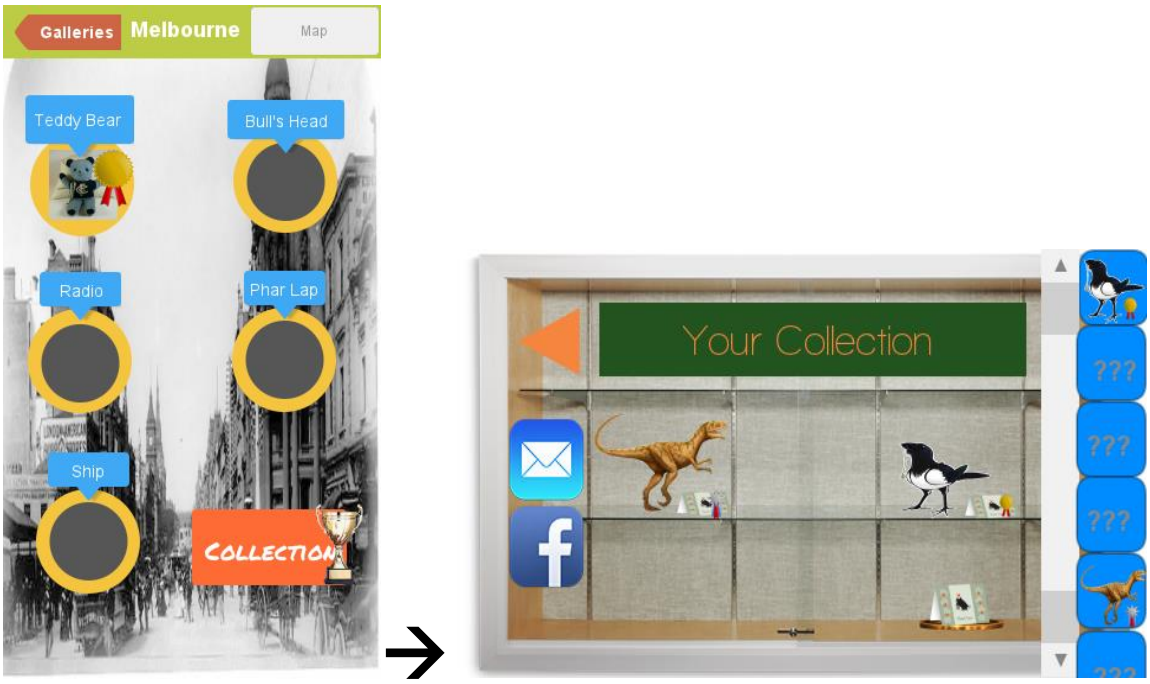

Figure 20: Digital prototype of gallery page to collection shelf

Each shelf would be empty until an item is found and that object fills its designated space. To inform the user that there are still items to collect for a given gallery, placeholder cards would sit on the shelf in the locations to be filled. There would be a collection shelf for each gallery, as well as one that is to be customizable by the player, allowing the user to gather their favorite objects on their own shelf and share via social media. The objects in the collection would also provide additional information should the user click on them (See Figure 21).

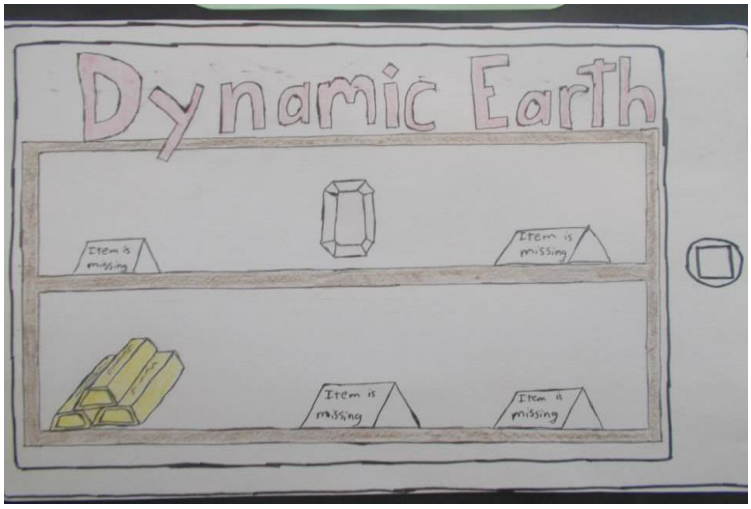

Figure 21: Sketch of object collection shelf

Reasoning

Our group felt that collecting badges did not generate enough motivation to complete the original *Time Lens* scavenger hunt. We wanted to emphasize the reason for finding objects throughout the museum and provide the user observable results. With the collection shelves, players are able to visualize and reflect upon their achievements. Reflection also allows users to return to the application after their visit and review the information about collected objects. We wanted the collection of objects to be relatively simple. This allows children in the younger target of our age group to feel accomplished without delving into the more challenging questions. Users who answer harder questions progress towards Silver and Gold Museum Medals. We decided to include a medal system to give the user a reason for completing the more challenging questions while still not detracting anything from those unable to answer them.

Map

Suggestions

The map would contain two separate images consisting of the first and second floor of the museum. These images would be detailed, high quality, and capable of zooming. The map would contain pictures and unique colors relating to each separate gallery. The different coloured galleries and images would be clickable and take the user to the specific gallery page when selected (See Figure 22). The map would also contain information about the location of restrooms and the café. If feasible, the map in the application would display the user's location in the museum through the use of Bluetooth technology.

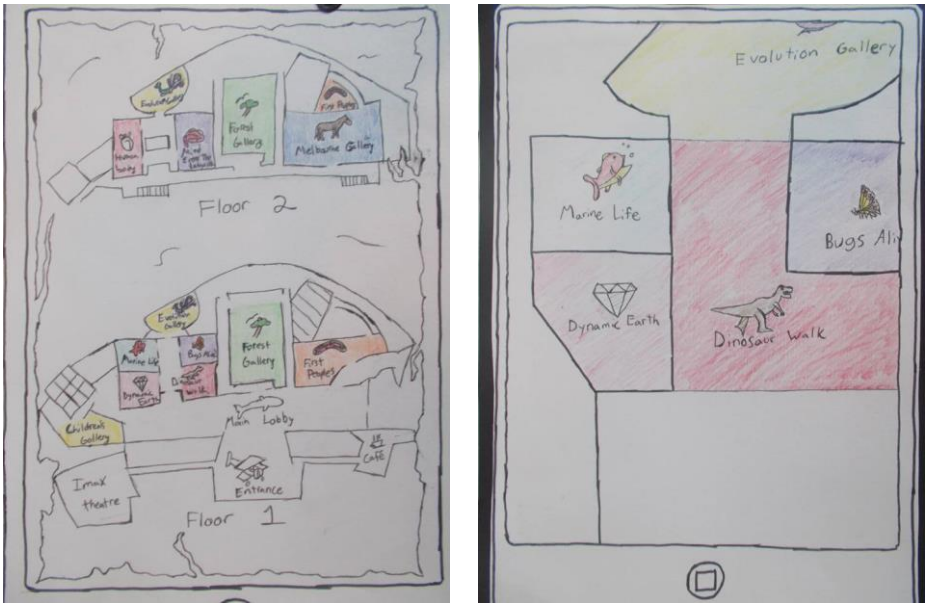

Figure 22: Sketch of map

Reasoning

According to our family and peer discussions, the map was one of the most crucial but least usable parts of *Time Lens*. Our team decided that it was important to give users an easy-to-understand map that contained details beyond the adventure itself. We believe the user should be able to find their way around the museum without consulting museum staff and the changes we suggest would achieve this.

Interface

Suggestions

The new interface would have a more intuitive, game-like feel. The user would navigate the application using large menu buttons that are easy to select. A main menu would display buttons directing the user to the map, galleries, collections, and help sections of the application (See Figure 23). The galleries would be laid out like the main menu in a tiered button system. Inside a selected gallery, the objects would be presented in a grid form, but with the iconic circular badge shape introduced in the first *Time Lens.* There would be links to the map throughout the application.

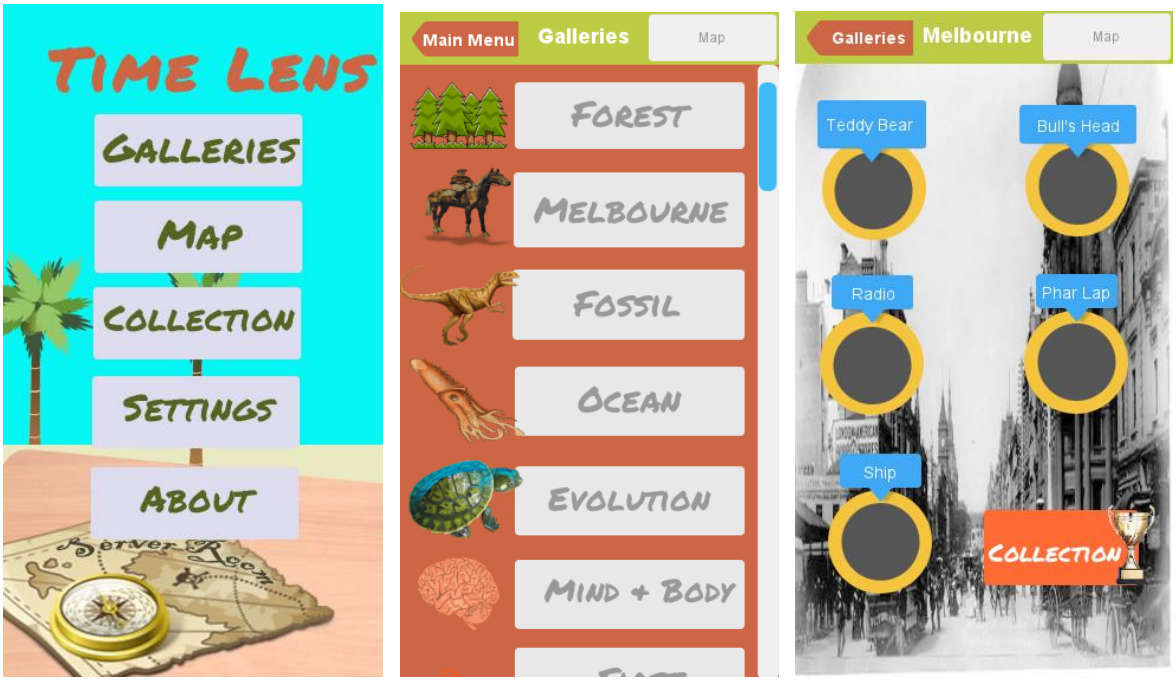

Figure 23: Digital prototype of main menu, galleries page, and object selection page

Reasoning

Users generally felt confused by the interface of the first *Time Lens*. Our team wanted the new application to be easy to understand with a short, gentle learning curve. We wanted to ensure users could still easily find their way back to the map and home page, so we want the new application to provide multiple links to these locations. We

feel that a game-style interface will create a better experience, as opposed to the tab system presented in the first *Time Lens*.

Survey

The new application would have a survey built in for ease of evaluation. Users would be prompted to fill out the survey upon completion of the application. The survey will take about five minutes to complete and would ask generalized questions about the application as well as a simple five star rating system. Adding a built-in survey saves time and money for the museum and can assist in the development of improved applications for a better visitor experience. This survey can be automated to add data to an easily accessible database. Although it will not provide the in-depth insight that an evaluation might, it gives developers quick feedback to determine whether the application is achieving its intended purpose.

Extras

Time Lens Episode II: The Curator's Collection can include a few selected 'smart objects' spread throughout the museum. These objects would provide a proof-of-concept for future technology implementations at the museum. Since Museum Victoria programmers have looked into using Bluetooth Estimotes in developing upcoming exhibits, we would like to help the museum trial them within this application. Having a few selected objects that use such a technology could solicit feedback and opinions from application users. This is a new and relatively unknown technology, so it is important to gauge visitor responses before implementing the technology on a larger scale.

These 'smart objects' would alert the user when they are close by using Bluetooth Estimotes and then prompt them to answer the questions pertaining to that object. The objects and questions would only alert people who are actively using the application. If the question is answered correctly, the collectibles appear on a collection shelf just like the other objects. If a visitor does not have Bluetooth capabilities on their device or has disabled it, it would not detract from their experience with our application. We seek to trial the technology, rather than base our application around it completely. This would allow the museum to test the feasibility and usability of 'smart objects' before using them as a widespread interactive.

4.6 Secondary Staff Interviews

Before our team finalized our preliminary design plans for the new application, we conducted several staff interviews. We showcased our initial plans and asked staff to suggest potential changes or any technical limitations they imagined. These interviews were conducted with many of the same staff members we questioned for our initial pre-evaluation interviews.

Our ideas were positively received by staff, reinforcing that they were both practical and designed for the best user experience. Staff liked the adventurous, explorative treasure hunt theme we created. They appreciated that we included Bluetooth technology in our designs, but that it was not a critical element of the application's design. This way, if Bluetooth were found to be unviable for the museum to use, it would remove some extra features but would not affect the entire structure of the application.

Staff members also had additional ideas for us to include in our suggestions to the museum. They thought we should propose that the museum take their own photos for use within the application. This way when sharing things through social media, they would not have to worry about getting permission from an outside company to allow posting the pictures online. Also, while Android devices natively have a back button in the device's operating system, Apple products require these buttons to be built into the application. Staff suggested that it is more intuitive for the user if these back buttons are labelled with regards to what screen it would return the user to. For example, the button might read 'Main Menu' instead of simply 'Back'. After collecting these opinions, we refined and confirmed the accessibility of both the developers and users in the creation of this second *Time Lens* application.

5. Conclusions and Recommendations

5.1 Conclusions about Application Development

The first episode of *Time Lens* received mostly positive feedback from users in the previous formative evaluation and our summative evaluation. Member and non-member visiting family groups felt that the application constructed a unique and educational museum visit. Our WPI student peers enjoyed the scavenger hunt system and the interactive connection *Time Lens* could create between children and museum objects. From these findings, we concluded that a new application in the Melbourne Museum would be an effective strategy to reach a wider range of child audiences. A more extensive and focused evaluation of the current *Time Lens* and future applications would be needed to assess effectiveness of the application's ability to increase learning, visitation, and revenue. While we are not developing technical components for the new application, our design ideas, based on feedback we received during the evaluation, will serve as the foundation for future development.

While there were many suggestions for improvements, we seek to continue the *Time Lens* brand and begin plans for a companion mobile application for use at the museum. The new application, titled *Time Lens Episode II: The Curator's Collection*, will not seek to replace the original *Time Lens*, but rather branch off and build on the established foundation. If this new application is to be successful in the museum, it must attract visitors and appeal to its desired audiences. During preliminary designs for the application, we considered and implemented many of the suggestions we received during our evaluation. With designs for improvements to the already existing features, we also implemented entirely new features that would capitalize on desired changes to the first *Time Lens* application.

5.1.1 Target Audience

Museums can effectively use mobile applications to craft an individualized museum experience. These applications can cater to specific age groups in order to attract a certain desired demographic. While the original *Time Lens* application was targeted for six to ten year olds, the older children within in this range felt as if they were not challenged enough by the application. From our evaluation, we found that children who were over eight years old did not benefit as greatly from using the application as younger children did. We would like the new application to target eight to twelve year olds to address this issue. If the museum were to continue producing applications in the *Time Lens* series, the next application could have a different target age or target group.

5.1.2 User-friendly Components and Way-finding

Based on visitor responses, the previous version of *Time Lens* lacked a user-friendly interface and understandable navigation system. With improvements suggested for the next episode of *Time Lens*, visitors would be better guided throughout the museum. Visitors who are unfamiliar with the museum can use the application with the addition of a better-designed map. However, this would not diminish the opportunity for personalization and exploration. Within each gallery, users can select whichever order they prefer for finding objects. The user's personal collection also allows for an aspect of customization. After collecting objects for the Courageous Curator, they could select what items to add to their personal 'favourites' shelf. These plans for the new application provide both structure and a degree of flexibility that we believe will satisfy all types of users.

5.1.3 Bluetooth Technology

The Melbourne Museum is exploring the option of using Bluetooth Estimotes to create 'smart objects' throughout the museum. If utilized within *Time Lens Episode II*, these objects would send notifications to the application users who have Bluetooth capabilities on their mobile device. We propose to trial this new technology in the new application by selecting a few selected 'smart objects' to be hidden throughout the museum. If the application user has Bluetooth capabilities on their mobile device, the object would be able to send alerts and messages through the application. We hope to gather visitor feedback and help the museum understand how the technology functions. If the museum decides to pursue use of this technology at another time, then *Time Lens* will have already provided a base understanding of how it works.

There are issues of potential privacy concerns if the application used Bluetooth technology. Since this technology could activate features on a user's device and track their location, it is important that the museum consider the repercussions when implementing such features. These potential problems would need to be addressed by the museum in order to ensure the success of any future mobile applications.

5.1.4 Room for Personalization

From our evaluation and research, we learned children enjoyed directing the museum visit while using *Time Lens*. Children are constantly exploring new technologies, whether in school, at home, or in other institutions like museums. New learning styles encourage personalization and sharing, claiming it creates more concrete memories for children. In the new application, users could create a personal collection shelf of their favorite objects. They could then share this collection with others via social

media. The collection shelf also serves as reference material for users after their visit to the museum. Users could return to the application and select the objects they have retrieved to see additional information.

5.2 General Recommendations

Many museums are developing mobile applications for visitor use. The Melbourne Museum has already jumped into this new field with the creation of *Time Lens*, and intends to continue discovering how these technologies can maximize the educational value and overall impact visitors take away from their museum experience. For this to happen, the museum must design applications that add something unique to the visitor's experience. The application cannot distract visitors from their environment, but must also be engaging enough to hold their attention.

5.2.1 Enhance Experiences

Museums use digital technology to enhance the user's educational experience, but must do so in a way to not divert attention from the exhibits themselves. There are critics that believe this balance is difficult to achieve and fear that mobile applications may be detrimental to a visitor's experience and the fundamental goals of museums. However, the majority of studies conducted show that well-designed mobile applications can effectively engage and educate visitors, and many visitors expect museums to be on the cutting edge in offering these kinds of technologies and experiences.

Through our summative evaluation, we concluded that the mobile application *Time Lens* successfully complemented exhibits within the Melbourne Museum. Families who participated in our evaluation said they discovered completely new things in the museum and learned new information about objects they had previously encountered. While many desired more content, they felt that the material included was educational and engaging. From these results, our team is convinced that a new mobile application, if it is well-designed and effectively marketed, can further enhance the visitor experience and family learning in the future.

5.2.2 Smartphone Usage

Museums are taking advantage of increased smartphone usage by implementing mobile technologies for use in their exhibits. The Melbourne Museum has developed multiple mobile applications and has continued research in emerging digital technologies. During our evaluation, we were prepared to provide museum member families with an iPod device pre-loaded with the current version of *Time Lens*. However, many families preferred to use personal devices. Since 84% of Australian adults own

smartphones, we determined it is efficient to develop applications for smartphone platforms (Luger, 2013). It would be costly for the museum to buy and maintain many loanable devices. Most visitors who would be interested in using the application are likely to have a capable personal device. Nevertheless, we recommend that the museum maintain a small number of pre-loaded devices for use by visitors who do not have smartphones. This approach can also be used as a marketing strategy to reach out to those who do not know about the availability of such apps at the museum.

5.2.3 Marketing

In our experience with museum members, very few knew about the current *Time Lens* application prior to the evaluation. For the new application to be successful, it must be well advertised. We hope that by continuing the *Time Lens* brand, marketing for the application will increase. This could boost publicity for the new application as well as the original version of *Time Lens* and result in more downloads and users. We suggest the museum include bright, exciting signs and posters at the museum entrance that reflect the theme and colors used in the new application. Informed customer service staff members should also promote the application to visitors. Many families who don't know about the application are interested in child-focused programs and would be likely to use the application if it were better marketed. Additionally, it is important to entice audiences through social media. Our team encourages the museum to promote the new application via the Museum Victoria website and other social media pages.

5.2.4 Built-in Survey

In our designs we included a built-in survey within the application. This will help determine the overall effectiveness of the application. A brief five to ten minute survey can provide the museum with simple feedback. Although this would not be as effective as a formative evaluation, it would not require the museum to plan and organize an event to gather general opinions. While a built-in survey can provide instantaneous feedback, it is important to consider how the data from this survey would be collected. First, the museum must consider if it is possible to design an application capable of sending data from a user's mobile device. Secondly, privacy matters must be considered when collecting information from a personal device.

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Appendix A – Sponsor Description

The National Museum of Victoria first opened in 1854 as a part of the Governmental Assay Office (Museum Victoria, 2013). The first exhibits were native flora and fauna, fossils, and geographical specimens. Today, this has expanded to form Museum Victoria network. It is the largest organization of public museums in Australia and the entire Southern Hemisphere. Its multiple locations house nearly 17 million objects, documents, photographs, and specimen. Museum Victoria seeks to attract a wide audience through fascinating, interactive exhibits and ever-changing galleries. The museum organization serves as a scientific and historic research centre that intends to "foster creativity" for future generations through education and preservation (Greene, 2012).

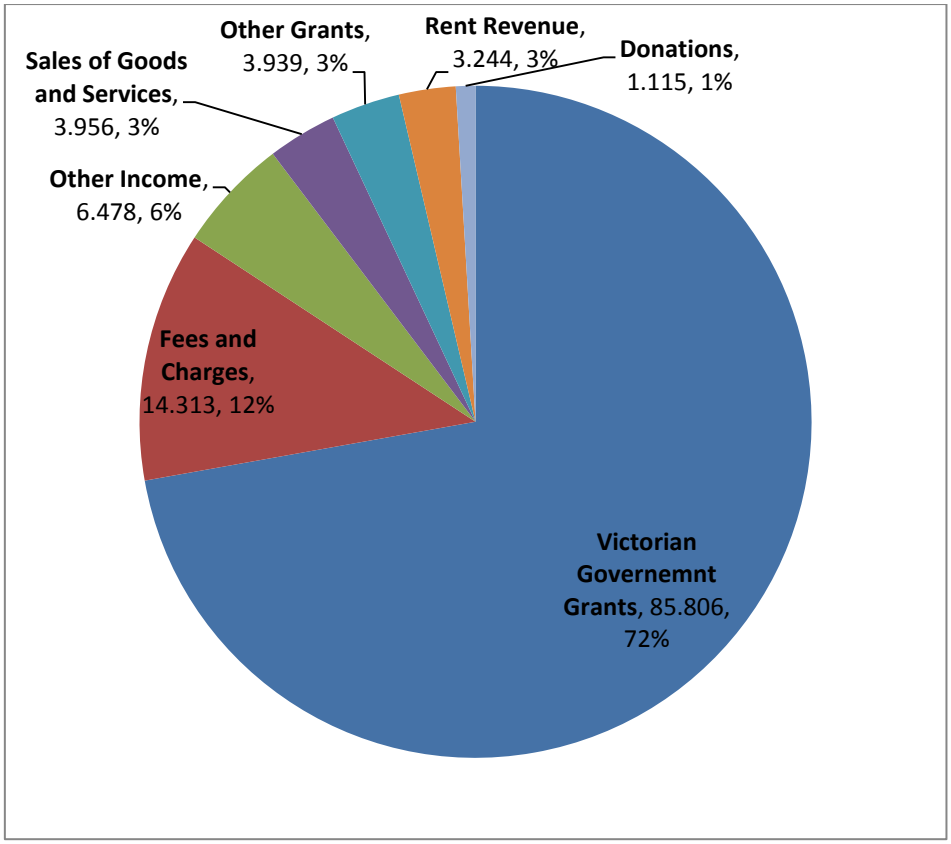

Figure 24: Income from transactions (millions)

All of Museum Victoria is a government owned not-for-profit organization. Museum Victoria is supported by donors, the Victorian and Australian governments, the City of Melbourne, and various other agencies. The museum receives $120 million (AUD) in income, of which approximately $86 million is funding from the Victorian government, $4 million from various other grants, $14 million from general admissions, and $4 million from the sales of goods and services (See Figure 24). Revenue increased

from 2007 to 2010 when both allocated government funds and received income from transactions increased (See Figure 25).

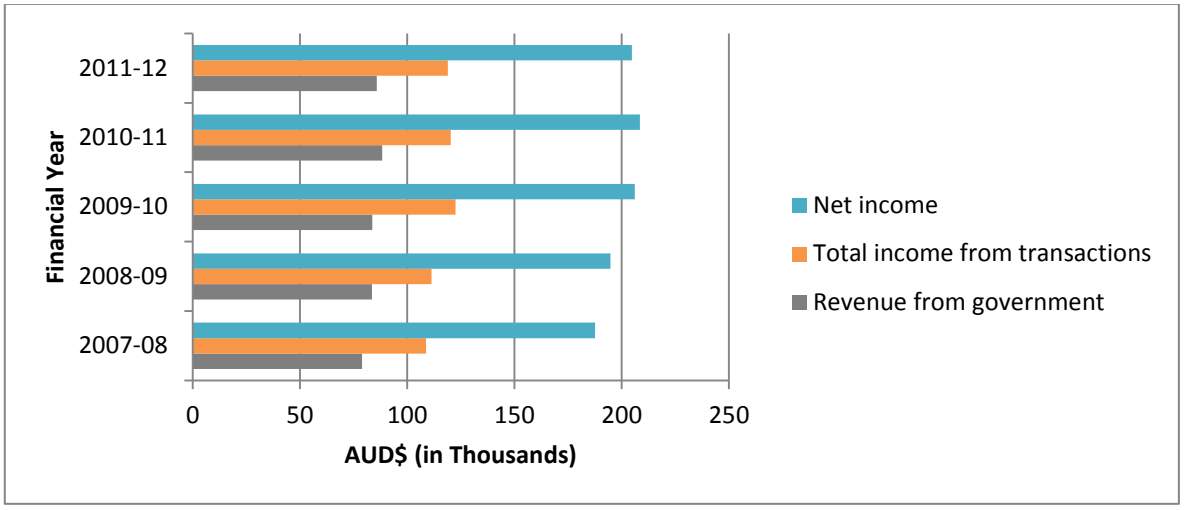

Figure 25: Revenue from transaction and government

Museum Victoria is an umbrella organization with several different venues within the city of Melbourne (See Figure 26). Museum Victoria operates three museums: the Immigration Museum, Scienceworks, and the Melbourne Museum. The organization also serves as custodian for the Royal Exhibition Building. The Immigration Museum is designed to engage visitors in the rich cultural history of Australia's society. Scienceworks aims to teach children about science and technology through the use of highly interactive exhibitions. The Scienceworks museum also contains a Planetarium and a Lightening Room, which features a Tesla Coil. The Melbourne Museum showcases a large variety of exhibitions ranging from the history of Melbourne to the human mind. The Melbourne Museum also houses the third largest IMAX movie screen in the world.

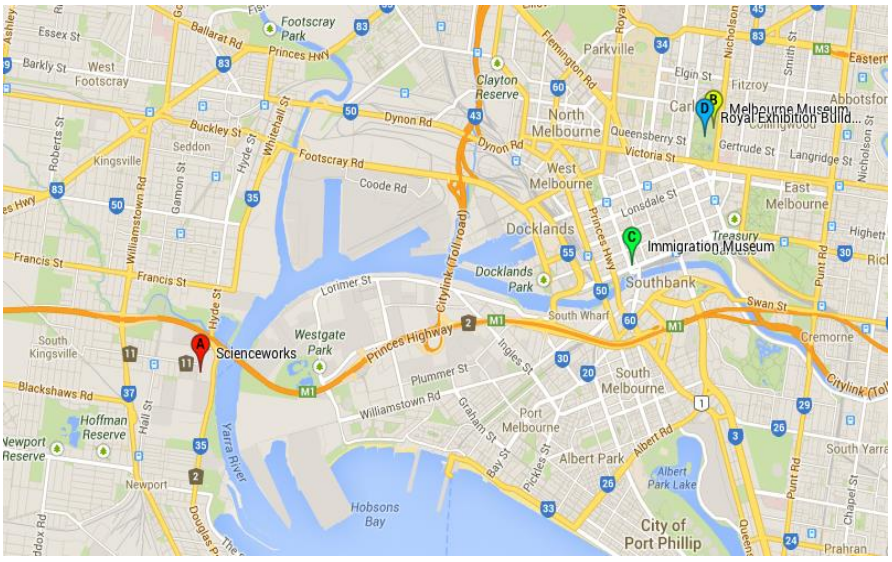

Figure 26: Museum Victoria venue locations

Museum Victoria boasted 2.3 million visits in 2010 alone. The Melbourne Museum has seen a steady increase in visitation from 2007 to 2011, reaching over two million visitors from 2010-2011 (See Figure 27). This has made the Melbourne Museum not only Museum Victoria's most visited venue, but also the most visited museum in Australia.

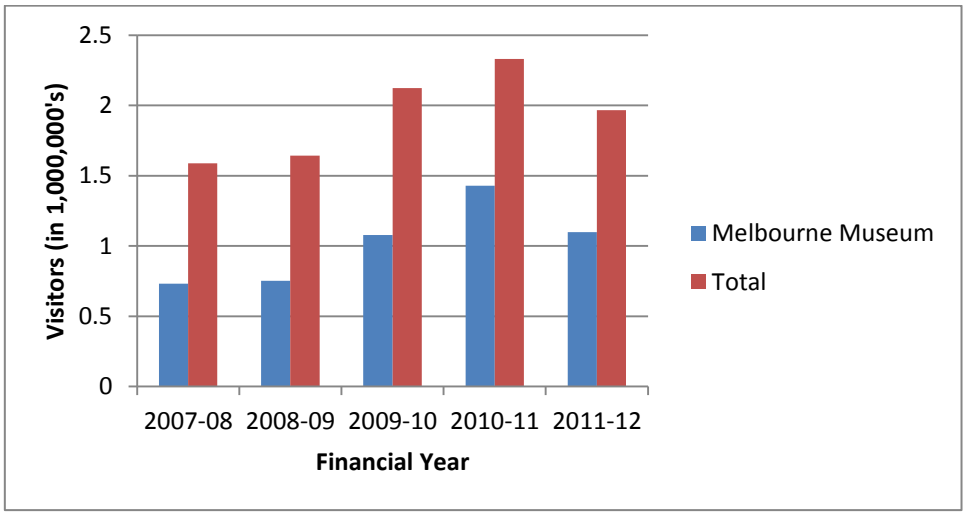

Figure 27: Annual number of visitors at Melbourne Museum

In 2010, Museum Victoria employed 773 men and women, an all-time high correlating with the trends of an increased number of visitors during those years. Museum Victoria currently employs approximately 450 full-time and 150 part-time employees organized in various departments (See Figures 28 and Figure 29).

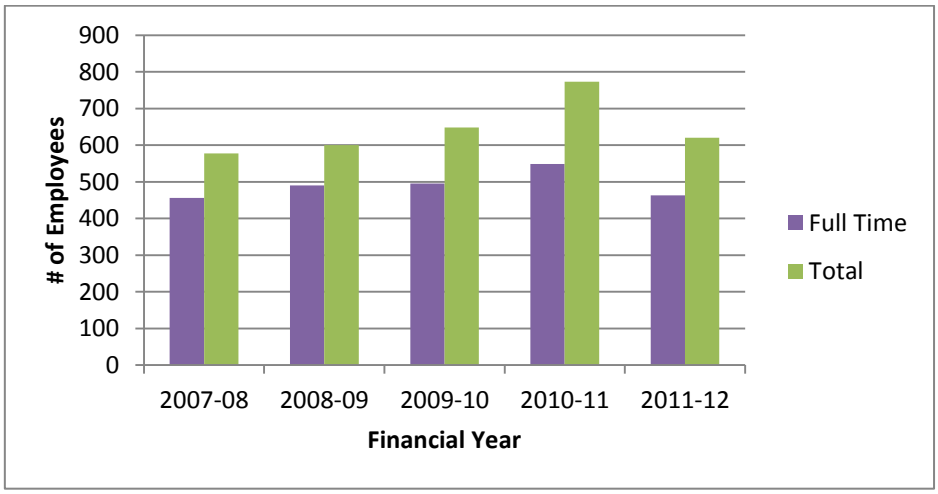

Figure 28: Museum Victoria employees

Figure 29: Museum Victoria organization chart

The Melbourne Museum is located in Carlton Gardens, across from the Royal Exhibition Building, as shown in Figure 26 (Museum Victoria, 2013). It is the most popular venue of Museum Victoria, with more than 1 million visitors annually in recent years. It has eight permanent galleries, one of which is specifically for children. There is a temporary gallery, known as the Touring Hall, which is home to the temporary exhibits, often from foreign museums (Museum Victoria, 2013). The most popular permanent exhibit in the Melbourne Museum is the great racehorse, Phar Lap, located in the Melbourne Gallery. This exhibit contains the actual hide of the great Depression-era racehorse. After winning almost every race in Australia, Phar Lap competed in the United States before his untimely death in 1923.

The museum categorizes its exhibits into four main groups including rocks and fossils, animals and plants, history and technology, and indigenous cultures. The museum emphasizes the educational value of its exhibits for students of all ages. Secondary school students can also partake in an Education Excursion Package focusing on Aborigines, evolution, or investigating various historical elements. Currently, the museum uses an interactive application titled *Time Lens Episode I: Treasures and Gems* to engage its visiting families with young children. *Time Lens* offers puzzles and riddles reveal significant museum objects when solved answer correctly. The application

seeks to excite visitors and provoke a deeper curiosity in to the various wacky and weird objects located throughout the museum with featured animations and achievement levels.

Appendix B – *Time Lens* Staff Interview

My name is ____. I am a member of a research team collaborating with Museum Victoria to evaluate the effectiveness of the *Time Lens* application. Since you are a member of Museum Victoria staff, your input on this application and your experience with its use would be helpful for preliminary observations. Would you mind answering a few questions pertaining to *Time Lens*?

1. Describe your role at the Melbourne Museum.
   - Important to note: department, title
   - How often do you work with the *Time Lens* application?
   - Do you have any additional information with digital applications similar to *Time Lens*?

2. What, in your opinion, is the goal of *Time Lens*?
   - Do you feel this goal is being satisfied?
   - *How did you work toward reaching this goal in the development of the app?
   - *How well do you feel this was achieved?

3. What are your observations of *Time Lens* in the museum?
   - Have you encountered any general visitor opinions? Staff opinions?
   - How much usage have you seen *Time Lens* receive?

4. Do you believe mobile applications like *Time Lens* will play a significant role in the future of museums?
   - Positive or negative impact?
      - Balance between learning and entertainment value?

5. Do you have any suggestions for adaptations from your observations and experience for future iterations of *Time Lens*?
   - What would be the most beneficial change to *Time Lens*?
   - What is something that works particularly well with the application that should be kept for future iterations?

**Applies only to employees directly involved in development of Time Lens.*

Appendix C – Observational Checklist

#Order of visit | Badge/Exhibit (POI) | Time Spent (MM:SS)

__ Tech Time Traveller __:__

POI: Biplane | phonograph | mouse

__ Fossil Finder __:__

POI: Tarbosaurus bataar | Thylacoleo carnifex | Qantassarus intrepidus

__ Wet and Wild __:__

POI: Wedge-tailed eagle | Fox | Squid

__ Forest Frolicker __:__

POI: Chimney | Bowerbird | Magpie

__ Marvelous Melbourne __:__

POI: Phar Lap | Cole's Little Men | Sanitary Pan

Total Time:

__:__

Other areas visited:

Appendix D – Non-Member Family Discussion Guide

1. Introduction

Aim: To help respondents feel more comfortable and give them details and reason for the *Time Lens* evaluation.

Privacy Act Requirements

- Please sign these privacy statements showing your consent to be recorded as a part of this research project. Your information is private and will be used for research purposes only. These records will be destroyed after the final report is produced.
- No right or wrong answers, we just want your honest opinion.
- You will have 1.5 hours for your visit, don't feel you need to use the entire time.
- Afterwards there will be a 30 minute discussion.
- Refreshments, toilets, mobile phones, etc...

2. Background & Warm Up

Aim: To gather background information & allow respondents to feel more comfortable

- Respondents to briefly introduce family
    - Names of family members
    - Ages of family members
    - Reason for museum visit
    -

3. Observations

Aim: To understand how *Time Lens* guides family groups, also to determine more/less effective exhibits and badges within *Time Lens.*

An observer will be chosen to track family with a clipboard using Appendix C – Observation Checklist. Observer will obtain data pertaining to the time spent at each exhibit and the order in which the exhibits were visited.

4. End of Visit Discussion

Aim: To evaluate the effectiveness of the digital application *Time Lens* for family groups with kids between the ages of 6-10.

1. **Group Dynamics**
    a. Who held the device for the majority of the time?

b. Were there any disagreements over who should be in control of the application?

2. **Navigation**
    a. Was this your first visit to the Melbourne Museum?
        i. **If no**: Did you visit something you wouldn't have because of *Time Lens?*
    b. Tell us about the path you took around the museum.
3. **Content**
    a. Do you feel the application included enough content from each exhibit?
4. **Entertainment**
    a. Was *Time Lens* fun for your family? (Kids & Adults)
5. **Education**
    a. Do you think your family learned something new as a result of using *Time Lens?* (Kids & Adults)
6. **Usability**
    a. Did *Time Lens* function correctly for the entirety of its use?
    b. Did you experience any major issues with the layout of *Time Lens?*
7. **Length**
    a. How did you feel about the length of *Time Lens?*
8. **Challenge**
    a. Did your kid(s) feel challenged by *Time Lens?*
9. **Major Changes**
    a. Are there any specific changes you would make to *Time Lens* based on your experience?

Appendix E – Peer Review Discussion Guide

1. Introduction

Aim: To help respondents feel more comfortable and give them details and reason for the *Time Lens* evaluation.

Privacy Act Requirements

- Please sign these privacy statements showing your consent to be recorded as a part of this research project. Your information is private and will be used for research purposes only. These records will be destroyed after the final report is produced.
- No right or wrong answers, we just want your honest opinion.
- You will have 1.5 hours for your visit, don't feel you need to use the entire time.
- Afterwards there will be a 30 minute discussion.
- Refreshments, toilets, mobile phones, etc...

2. Observations

Aim: To understand how *Time Lens* guides family groups, also to determine more/less effective exhibits and badges within *Time Lens.*

An observer will be chosen to track family with a clipboard using Appendix C – Observation Checklist. Observer will obtain data pertaining to the time spent at each exhibit and the order in which the exhibits were visited.

3. End of Visit Discussion

Aim: To evaluate the effectiveness of the digital application *Time Lens* as a technical mobile application.

1. **Usability**
    a. What did you think of the layout of *Time Lens?*
        i. Menus, question pages, badges etc…
    b. How easy was it to navigate *Time Lens?*
2. **Content**
    a. What did you think of the content of *Time Lens* itself?
        i. Riddles, Animations, Age appropriate, etc…
    b. Did you think the theme of *Time Lens* was appropriate?
    c. Do you feel *Time Lens* included enough content from each exhibit?

3. **Challenge**
    a. What do you think about the difficulty of the questions?
4. **Navigation**
    a. How did you feel about *Time Len's* ability to lead you around the museum? (open ended or more structure)
5. **Length**
    a. How did you feel about the length of *Time Lens* and the amount of time you spent on it?
6. **Education**
    a. Did you think *Time Lens* had enough educational value?
7. **Entertainment**
    a. Did you have fun using *Time Lens?* (fun for 6-12?)
8. **Group Dynamics**
    a. Did you encounter anything that might be a problem for kids using *Time Lens?* (running off, being loud etc…)
9. **Major Changes**
    a. What changes, if any, would you suggest for a new *Time Lens?*
10. **Enhancement**
    a. In what ways do you imagine *Time Lens* affecting museum visits?
    b. Positive or negative?

Appendix F – Member Family Discussion Guide

1. Introduction

Aim: To help respondents feel more comfortable and give them details and reason for the *Time Lens* evaluation.

Privacy Act Requirements

- Please sign these privacy statements showing your consent to be recorded as a part of this research project. Your information is private and will be used for research purposes only. These records will be destroyed after the final report is produced.
- No right or wrong answers, we just want your honest opinion.
- You will have 1.5 hours for your visit, don't feel you need to use the entire time.
- Afterwards there will be a 30 minute discussion.
- Refreshments, toilets, mobile phones, etc...

2. Introduction

Aim: To gather background information and allow respondents to feel more comfortable

- Respondents to briefly introduce family
    - Names of family members
    - Ages of family members

3. Observations

Aim: To understand how *Time Lens* guides family groups, also to determine more/less effective exhibits and badges within *Time Lens.*

An observer will be chosen to track family with a clipboard using Appendix C – Observation Checklist. Observer will obtain data pertaining to the time spent at each exhibit and the order in which the exhibits were visited.

4. End of Visit Discussion

Aim: To evaluate the effectiveness of the digital application *Time Lens* for family groups with kids between the ages of 6-12.

1. **Usability**
    a. Did *Time Lens* function correctly for the entirety of its use?
    b. Did you experience any major issues with the layout of *Time Lens?*
2. **Navigation**
    a. Tell us about the path you took around the museum.

b. Did you use the map within the application?

3. **Group Dynamics**
    a. Who held the device for the majority of the time?
    b. Were there any disagreements over who should be in control of the application?
4. **Length**
    a. How did you feel about the length of *Time Lens* and the amount of time you spent on it?
5. **Content**
    a. Do you feel the application included enough content from each exhibit?
6. **Education**
    a. Are there any facts you learned using the application that you did not take from the museum prior to today's visit?
7. **Challenge**
    a. Were the riddles and puzzles challenging enough?
    b. Did you feel the questions in the application encouraged you to hunt for an answer?
8. **Entertainment**
    a. How did you like the Curious Curator character?
    b. Did you find the animations useful and interesting?
9. **Enhancement**
    a. Did you discover anything new at the museum that you have not encountered before?
    b. Did the application enhance your overall experience at the Melbourne Museum?
10. **Major Changes**
    a. Are there any specific changes you would make to *Time Lens* based on your experience?

Appendix G – Recruitment Script

Hello, my name is _____. I am an American Student currently in the process of evaluating Time Lens. I will provide a device so you do not have to download the application on your own. Are you interested?

(YES / NO)

Excellent, all we need is for you to use Time Lens during your visit and complete a closing survey upon finishing using the application. Your actions may be observed and we will need to hold your driver's license while the device is being loaned out to you.

Thank you and I hope you enjoy the *Time Lens* application!