



WPI

Worcester Community
Project Center

ENGAGING THE VISITOR WITH DIGITAL TECHNOLOGY IN THE ARMS AND ARMOR COLLECTION

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ABSTRACT

The Worcester Art Museum is seeking to incorporate the Higgins Armory collection into its galleries and simultaneously increase visitor engagement by implementing technologies appropriate to the exhibit and target audience. In addition to developing an iPad implementation, our project provided recommendations for accomplishing this in the Meyer Idea Lab and the Medieval Gallery. To accomplish our goal, we visited museums with interactive exhibit designs, interviewed museum staff, observed visitors, and surveyed visitor responses to the available media. Our project culminated with a promotional video on arms and armor, the informational iPad implementation, analysis of visitor survey data, and recommendations for future exhibits at the Worcester Art Museum.

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EXECUTIVE SUMMARY

INTRODUCTION

Museums today are increasingly focused on visitor education and engagement (Hein, 1998) in addition to their traditional roles of collection, conservation, and research (Lord & Piacente, 2014; Alexander, 1979). The Worcester Art Museum (WAM) wishes to seize the opportunity of acquiring the arms and armor collection from the Higgins Armory Museum (Higgins) in 2013 to better engage and educate their visitors, and simultaneously accomplish their 2020 goal of 200,000 visitors (Worcester Art Museum, 2014). According to the curator of Arms & Armor and Medieval Art, the Higgins collection primarily targets families (J. Forngeng, personal communication, February 10, 2016).

The WAM wants to proceed by increasing interactivity by including digital media in the upcoming Meyer Idea Lab, a temporary exhibit opening May 28, 2016 (“Jeppson Idea Lab: The Art of Combat”, n.d.) and the Medieval Gallery, a permanent exhibit opening in December 2016 (J. Forngeng, personal communication, February 10, 2016). However, our sponsor wanted additional research on the various information media implemented in other museums and greater analysis of the digital technology already implemented in the Knights! exhibit (J. Forngeng, personal communication, February 10, 2016). For these reasons, the WAM engaged a team of student researchers from WPI to research the use of digital media, primarily iPads, in the museum. Thus, we focused on researching and finding the best way to implement digital technology. We also researched other methods of engagement not limited to digital technology.

METHODOLOGY

The Worcester Art Museum’s Curator of Arms & Armor and Medieval Art, Jeffrey Forngeng, requested that we research the effectiveness of different media in engaging family

audiences and also create the iPad implementation for the Meyer Idea Lab, in addition to posing recommendations for both the Idea Lab and the Medieval Gallery. We achieved our goal using the following six objectives:

1. Evaluate the current state of the Worcester Art Museum, particularly its arms and armor collection and its current implementation of iPads and other educational media.
2. Identify museums with engaging exhibits, especially those using iPads, and consult their staff on implementation strategies.
3. Analyze and evaluate success of engagement techniques from Objectives 1 and 2.
4. Design and develop a personal promotional video of arms and armor at the WAM.
5. Design and develop a digital media implementation for the iPads.
6. Provide recommendations for the Meyer Idea Lab and Medieval Gallery.

We realized our goals by using a variety of methods. To better understand the educational media available at the WAM and how it was being used, we analyzed survey data, conducted participant observation in the Knights! exhibit and Remastered, conducted oral surveys of visitor experience with the iPads, and interviewed guards. We also interviewed eight WAM staff, including educators, the arms and armor curator, and the director of audience engagement to better understand the vision for the arms and armor collection.

We conducted online research to identify museums with similar target demographic, collection, size, or location to the WAM. We interviewed museum staff at nineteen other museums and visited the Worcester Historical Museum, the EcoTarium in Worcester, the deCordova Sculpture Park and Museum, the Museum of Fine Arts in Boston, the Museum of Science in Boston, and the Museum of Russian Icons to explore different methods of visitor engagement and observe how visitors experienced these methods. We assessed the effectiveness

of the exhibit design and engagement techniques using the following criteria: accessibility, sustainability, learning style, and visitor appeal. We found these criteria very important for the WAM to appeal to a wide demographic of families, to cater to various levels of knowledge using a variety of educational methods, and to surpass Americans with Disabilities Act (ADA) standards while being realistic for extended use in the permanent galleries.

FINDINGS

From our research at twenty museums, we concluded many things about improving family visitor engagement. First, we found that museum curators, educators, gallery attendants, and visitors have differing views on the role of the art museum. Next we were surprised to learn that contrary to previous beliefs, overall attendance rates at New England museums are increasing. However, in the WAM and other New England Museums, the people showing up do not always correspond to the demographic targeted. When we looked at the effect of technology, we found that depending on how it is used, technology can be beneficial, detrimental, or simply inconsequential in engaging a family audience. We also found out that most museums have similar ways of designing and implementing their technology. Although not originally part of target research, we found that layout of exhibits play a key role in audience engagement. Finally, observations and surveys at the WAM showed that the trends we examined at other museums hold true here as well.

DELIVERABLES

We created two multimedia deliverables for the WAM. The first was a video about the life and writings of Joachim Meyer, the author of the *Art of Combat* fencing manual produced in the sixteenth century. The light-hearted video featured descriptions of fencing techniques and weapons, swordplay demonstrations, and trivia. The second was an iPad interactive for the

Meyer Idea Lab opening at the WAM in May 2016. Our findings influenced the six features, including detailed slideshows on sword fighting and the works of Meyer, exploration of one of the woodcut illustrations found in the *Art of Combat*, a video demonstration of some of the swordplay techniques found in the fencing manual, and an interactive fencing game created by a previous research team working with the arms and armor collection. Finally, we implemented a visitor tracking system on the app to record how long visitors interacted with different features.

RECOMMENDATIONS

From our findings, we created a list of recommendations for technology implementation at the WAM in both the Medieval Gallery and future exhibits. We based these recommendations on a desire to provide a multisensory experience that targets a family audience. This includes using a variety of low-tech solutions with a focus on visual learning strategies and an avoidance of technological distractions. We deemed labels, audio stations, ambient music, video, magnifying glasses, printed guides, books, and arts and crafts to be appropriate for family audiences at the WAM. We also found that multisided exhibits are particularly important to allow access by a group or family. Additionally, we stressed the importance of providing rest areas with seating, and recommended designing nonlinear exhibits for free choice exploration.

Conclusion

The Worcester Art Museum has already made great strides towards better engaging family audiences. Exhibits such as Knights! have already implemented many of the recommendations that we formed from our findings. We believe that the iPad application we developed will help to address the low usage rates of tablets in the past, and that the visitor tracking software will improve the iteration process for WAM tablet application design. We also believe that the video we created will help draw attention to the Meyer Idea Lab and swordplay

workshops. Finally, by implementing our recommendations, we are confident that the WAM can better provide families with a personalized and self-guided museum visit that incorporates sight, sound, and touch for a more immersive and engaging experience.

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1. INTRODUCTION

Museums today are undergoing a paradigm shift in their atmosphere, audience, methods of engagement, and other key facets. Historically, the majority of museums placed their focus on acquiring a large collection, performing research (Alexander, 1979; Falk & Dierking, 2008), and conservation efforts (Alexander, 1979). The desires of communities have changed however, and according to the National Endowment for the Arts, museum attendance has been dropping since 2002 (National Endowment for the Arts, 2012). In response, more museums have been shifting focus towards engaging and educating their visitors in a much less formal setting according to New York Times editor, Michael Cannell (2015). According to Hein, Professor Emeritus of Science and Museum Education at Lesley University, museums must appeal to a diverse audience by promoting their educational role (1998). In an effort to attract different demographics, museums may change their approach to exhibit design and visitor's experience through a variety of learning methods.

The Worcester Art Museum has been facing difficulties in engaging visitors and persuading them to return (J. Forgeng, Personal Communication, February 10, 2016). The Worcester Art Museum (WAM) is an important institution, established in 1898, that is committed to serving as a cultural resource for its community. The WAM's 2013 Annual Report shows its past success as a 44% increase in visitors over the course of two years, rising from 51,459 recorded in 2011 to reach 74,190 in 2013. However, this increase can be partially attributed to the promotional one month of free admissions occurring during summer each year. By 2020, the WAM aims to reach an annual attendance level of 200,000 and to become a cultural landmark of New England (Worcester Art Museum, 2013). To accomplish this, the

WAM seeks to continue its improvement of visitor engagement and education, resulting in more satisfied visitors and more popularity for the museum.

In WAM's 2014 Director's Report, Director Matthias Waschek expressed an interest to expand their visitor base and appeal to a wider demographic (Worcester Art Museum, 2014). The Worcester Art Museum wishes to expand their collection and enhance their exhibit designs to provide visitors with an experience that inspires learning and fosters community growth. When the Higgins Armory Museum closed in 2013, its collection was absorbed by the WAM. For 83 years, the Higgins Armory Museum (Higgins) attracted families with children. The WAM plans to gradually display more of the artifacts and form a unique cultural experience for its visitors.

The WAM has already started incorporating the Higgins collection into its exhibits. The Knights! exhibit, on display at the WAM from March 29, 2014 to November 6, 2016 displays some of the Higgins collection and exemplifies the attempts to modernize the exhibits, and thus potentially increase visitor engagement, using digital technology and hands-on interactives. However, according to Jeffrey Forgeng, curator of Arms & Armor and Medieval Art at the WAM, the Knights! exhibit was designed primarily to showcase the artistic elements and not to develop historical context (personal communication, February 10, 2016). Thus, the collection lacks the narrative and time-period immersion that had been prominent in the Higgins. Although the WAM intends to move forward with the shift of education and engagement methods with its Spring and Fall 2016 arms and armor exhibits, the Meyer Idea Lab and the Medieval Gallery, doing so effectively required further research and evaluation of the Knights! exhibit methods of presenting information and engaging visitors.

With its acquisition of approximately 2,000 items from the Higgins (Worcester Art Museum, 2014), a great deal of planning is required to best produce the new exhibits as only a

fraction of the artifacts can be displayed due to size constraints. According to Jeffrey Forgeng, curator of Arms & Armor and Medieval Art, effectively implementing technologies is pivotal to successfully engaging visitors (personal communication, February 10, 2016). The WAM wants to learn more about how digital technologies are implemented in other museums and how visitors feel about the digital technologies used in the Knights! exhibit (2015), so the WAM's curator of Arms & Armor and Medieval Art sought a team of researchers from Worcester Polytechnic Institute to determine appropriate methods of engagement.

With the guidance of Jeffrey Forgeng, we analyzed existing research, performed first-hand field research on exhibit design, and determined common factors in exhibit design and how they affect the overall visitor experience. We evaluated the strengths and weaknesses of each exhibit design strategy and the feasibility of combining them with other strategies to accommodate different learning styles and to appeal to the entire family, a key demographic for the WAM. Finally, we compiled a list of suggestions and other deliverables for the WAM's implementation of the Meyer Idea Lab. These findings will be implemented in the Idea Lab and applied to future exhibits. This research will improve the WAM's service to its visitors, providing better learning and bonding opportunities for its family visitors.

In the next chapter we explore important factors we discovered by examining the literature. The topics we investigated are the significance of art museums, the significance of history museums and how they differ from those of art museums, museum attendance, methods of engagement, and the current state of the WAM's educational utilities and the arms and armor collection. In Chapter 3, we provide the methods we use to achieve our goal of better engaging families in the arms and armor exhibits. Also included are our methods for developing a promotional video and iPad implementation for visitor engagement and usage in the Idea Lab. In

Chapter 4, we discuss findings, including underlying trends and causes behind the raw data collected as well as themes arising from multiple interviews with different museum experts. Finally, in Chapter 5 we provide our list of recommendations, formed by considering the findings and implementing them in a manner plausible for the WAM. We provide recommendations for general application, as well as investigate the strengths and weaknesses of different technologies, and how to optimize their usage appropriately.

2. BACKGROUND

The very first collections, called cabinets of curiosities, were closely guarded and private so only a select few individuals were permitted to see the collector's hoarded artifacts (Hein, 1998; Silverman, 2010). The first public museums appeared in the 1700s, seeking to educate and entertain the general public. With industrialization, the museum became a primary means of educating the masses according to George Hein, Professor Emeritus in the Graduate School of Arts and Social Sciences (1998). More recently, modern museums were highly valued as a means of informal learning; museum staff began considering education and engagement in addition to research and collection, according to John Falk and Lynn Dierking, professors of Free-Choice Learning and Science Education respectively at Oregon State University (2008). In 2005, Hein presented the museum as a "major public social investment" responsible for providing active learning opportunities, facilitating personal meaning making, and seeking the improvement of society. According to a study in Britain conducted by the Museums Association, visitors believed that museums should promote economic growth, provide public education, and promote happiness and well-being without taking on other roles that might hinder these functions (Museums Association, 2013). The four major roles of a museum discussed by many sources are presented in Figure 2.1.

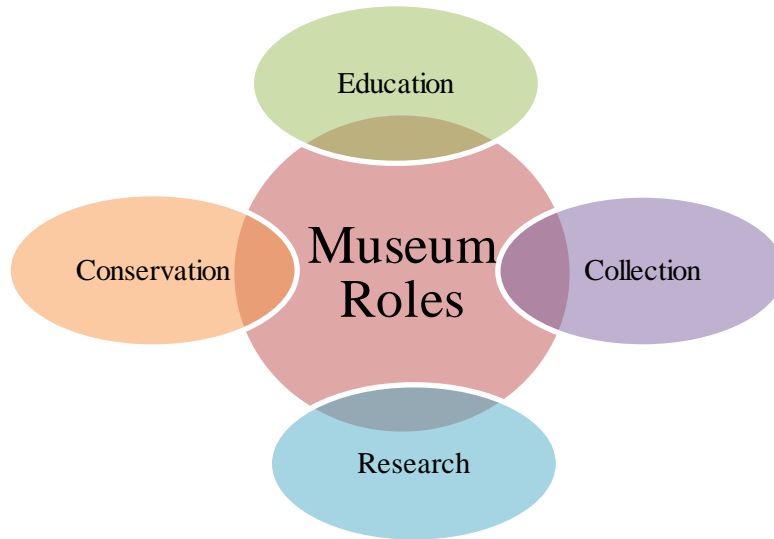


Figure 2.1: The Roles of a Museum (information from Alexander, 1979)

In sections 2.1 and 2.2, we examine the evolving significance of art and history museums, respectively. In section 2.3, we discuss changes to museum attendance. Sections 2.4 and 2.5 deal with appealing to a variety of visitors on the scale of a museum and then on the scale of individual exhibit components, respectively. Section 2.6 establishes the status of the Arms and Armor collection in the Worcester Art Museum at the end of April, 2016.

2.1. SIGNIFICANCE OF ART MUSEUMS

Most private collections were comprised of art pieces, such as the royal collections of Europe which were used to amass national collections of art. According to Edward Alexander, a historian and museum administrator, the Louvre in Paris was the first great national art museum, although symbols of the aristocratic regime were purged as the revolutionaries argued that the nation's art belonged to the people (Alexander, 1979). Pictures lined the walls from floor to ceiling, and the arrangement was haphazard with no labels to educate the average visitor. The collection was comprised of pillaged items from Belgium and Italy, and this was justified in part by the desire to conserve artwork. The museum was additionally financed through public funding

and donations from the Friends of the Louvre, which was formed in 1897 (1979). In the United States, art museums were slow to develop. The first collection of American art was displayed starting in 1805 in the Pennsylvania Academy of Fine Arts, along with annual exhibitions and art education. The Boston Athenaeum collected art pieces and later gave them to the Boston Museum of Fine Arts, which was established in 1870. The Metropolitan Museum of Art (MET) in New York was established the same year, and modeled on the Victoria and Albert Museum in London (Alexander, 1979).

Art museums have faced many challenges, including accessibility, relevance, and inclusiveness (Alexander, 1979; Salazar-Porzio, 2015; Govan, 2013). To be accessible, museums must provide adequate services and assistance to all visitors, regardless of disability or social context (Silverman, 2010; Dodek, 2012). Relevance requires a museum to appeal to visitors on a personal level (Hooper-Greenhill, 2000; Silverman, 2010). The art museum sought to appeal to a general audience and become more inclusive, but historically it attracted the middle class (Alexander, 1979; Woodson-Boulton, 2012).

Art museums should be accessible to everyone, facilitating family interaction and learning regardless of the family situation outside of the visit, according to Nina Simon and Lois Silverman, Executive Director of the Santa Cruz Museum of Art & History and professor in the Department of Recreation and Park Administration at Indiana University, respectively (2010; 2010). A variety of media, including tactile, auditory, and olfactory, should be equally accessible to all visitors regardless of disabilities. A study conducted at the Boston Museum of Fine Arts, where 252 visitors attended either an ordinary or multi-sensory tour, found that those who attended the interactive tours were able to make more connections to their own lives and recall more details (Dodek, 2012). This reveals that engaging visitors through a variety of senses,

including hearing, smell, sight, and touch, creates a more memorable and relevant experience for visitors than is traditionally offered at museums.

The museum is further challenged to remain relevant to society (Alexander, 1979; Salazar-Porzio, 2015). Thus, the art museum must choose its primary functions, among them collection, conservation, research, exhibition, interpretation, performing arts, community services, and multimedia happenings (Alexander, 1979). According to a 2011 study of family interaction in art museums by Karen Knutson, Kevin Crowley, Jennifer Lin Russell, and Mary Ann Steiner, art museums remain valued as places of informal learning, where they are to inspire collaboration between visitors (Knutson et al., 2011). In particular, the decor of the museum should promote a collaborative experience for the parent and child where the parent feels comfortable encouraging, guiding, providing recommendations, and finally participating alongside their child (Knutson et al., 2011). According to Andrea Witcomb, Curator at the Australian National Maritime Museum and National Museum of Australia, museums enclose objects like mausoleums and they seem frozen in time without context and outside the realm of the living (2003).

The art museum inspired the history museum, with the first historical collections containing portraits and busts of scholars, poets, artists, and rulers (Alexander, 1979). As a result of the nationalism prevalent in Europe in the 1630s, artwork portrayed battle scenes by commission as a way of romanticizing warfare (Alexander, 1979).

2.2. SIGNIFICANCE OF HISTORY MUSEUMS

There are numerous methods of presenting historical collections to museum visitors. Some museums displayed their collection as a panorama with the visitor at the center, where the curator attempted to make visitors feel as though they entered into the time period. One early

instance of this kind of engagement was the 1830 Battle of Navarino exhibit, where the visitor entered between decks of a ship into the midst of a battle generated by the sounds of men working in the exhibit and fighting sailors made from wax (Alexander, 1979). Another approach was to devote every room to a certain time period. Although this dictated a massive museum collection, it provided a unity of vision that can be easily understood. Presenting objects in cases allowed the visitor to compare similar items. Similarities could be based on time period or style, such as showing a series of weapons from the same time period or the transition of a particular longsword over the ages. According to Edward Alexander, a historian and museum administrator, it is beneficial for the museum to use a combination of arrangements to address the different desires of the audience and to support a variety of experiences (Alexander, 1979). Storytelling is used to engage visitors in the exhibit according to Christian Waltl, former curator for education in museums in Vienna, Austria and manager of the Provincial Museum Carinthia (2006). History museums are able to present exhibits as modern interpretations of past events to best connect with their audiences (Hein, 1998).

One purpose of a history museum was to unite the past with the present, and to provide a means of interaction between an artifact and a visitor (Alexander, 1979). When a visitor was truly engaged, he or she is able to relate the information back to his or her own experiences. Most attendees do not visit purely for intellectual reasons, but also because they are intrigued by a special exhibition or motivated by the social aspect of visiting (Waltl, 2006). In addition, as other major institutions decline, museums become more important as interpreters and preservers of culture according to Hein (1998).

The challenges a history museum must address mostly stem from the divide between the continuum of history and the static nature of museum objects. Objects by themselves give an

incomplete picture. A main issue that history museum curators must consider is how to make an object convey a dynamic and continuous flow of the human experience (Alexander, 1979).

2.3. MUSEUM ATTENDANCE

Museum staff construct and organize the museum with the needs of visitors in mind. Without visitors, museums would not function; thus, knowing the demographics that made up a museum's audience is a key to long-term success. According to Peter Samis, Associate Curator of Interpretation at the San Francisco Museum of Modern Art, museum visitors' motivations can be defined by three contexts: (1) the *personal context*, (2) the *social context*, and (3) the *physical context* (Samis, 2007). First, the *personal context* includes an individual's knowledge and experience, which often motivated the individual to go see artifacts. Second, the *social context* comprises of the circumstances of the visit, and the people that accompanied the visitor. Whether alone, with friends and coworkers, or with the whole family, visitors can have vastly different experiences depending on who was around them. For example, visiting a museum with an impatient companion eager to leave will significantly reduce the time you spend with a fascinating interactive (Samis, 2007). Lastly, the *physical context* distinguishes one museum from another, and is used to characterize the aura, appearance, and collection. For example, when visitors feel uncomfortable breaking the silence in a museum, this discourages interaction among groups of visitors. Together, these contexts make up the visitor's museum experience (Falk et al., 2008; Samis, 2007).

According to a ten year study conducted by the National Endowment of the Arts, there was a 5% decrease in art museum attendance between 2002 and 2012 throughout the United States. During this time, only attendance of those over 75 years of age increased (National

Endowment for the Arts, 2012). See the percentage of people in the age group who visited art museums in 2002 compared to 2012 in Figure 2.2.

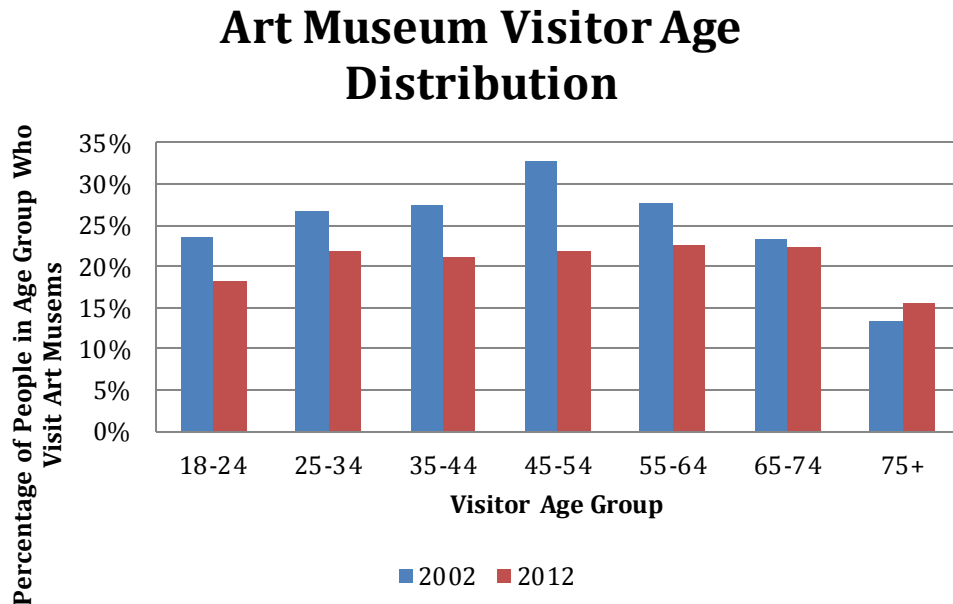


Figure 2.2: Percentage of Art Museum Visitors in a Particular Age Group from 2002 and 2012 (<https://www.arts.gov/sites/default/files/2012-sppa-feb2015.pdf>)

In order to combat declining attendance, museums must adapt their strategies of enticing people to visit the first time and then to return.

2.4. DRAWING A CROWD

What attracts new visitors to a museum, and what keeps them coming back again? The traveling museum, roaming caravans prevalent in the times of private collections, once attracted entire families with their exciting atmosphere and novelty (Miles & Zavala, 1994). Modern museums introduced novelty and wonder to attract larger audiences by housing special exhibitions, according to Barry Lord, co-President of Lord Cultural Resources and expert in museum management and planning, and Maria Piacente, Vice President of Exhibitions and Events at Lord Cultural Resources (2014). Indonesia's National Museum discovered through a

survey that 62.5% of visitors came to their museum for their program where theater performers told stories attached to the items on display (Soerjoatmodjo, 2015).

But what does a museum do once the crowd arrives? Unlike the traveling museum of the past, modern museums attract visitors year round, and during regular hours. Exhibits must rely on a variety of interactive methods, rather than just live performance, to engage visitors (England, 2014). According to Nina Simon, Executive Director of the Santa Cruz Museum of Art & History, an engaging exhibit must be accessible and relatable to its audience, allowing visitors to construct their own meanings and share their opinions (2010).

2.5. METHODS OF ENGAGEMENT

The role of the art museum transitioned, according to Edward Alexander as a result of industrialization beginning in the 1800s, from the traditional focus on collection, conservation, and research to greater emphasis on public education (Lord & Piacente, 2014; Alexander, 1979). To address this new function as an institution of informal learning, the method in which museum staff presented their collections also changed (Carliner, 2001).

Museum staff usually sought to address a larger and often unknown audience, but according to Eileen Hooper-Greenhill, Emeritus Professor of Museum Studies at the University of Leicester, the generalized conception of a mass audience further distanced the museum from its visitors; rather, museums should conduct research on their particular audiences to tailor their exhibit to their visitor base (2000). Professor of Heritage Fiona McLean addressed the importance of knowing your audience, arguing that by knowing and actively targeting a demographic, museums would attract more visitors and would secure better funding. For example, if the purpose of the exhibit is to educate, the best place to market the exhibit is to a place of learning, such as a school or university (McLean, 1997). To engage today's visitor,

museums must create distinct experiences, meeting expectations for engagement and education (Carliner, 2001).

Philadelphia Informal Science Education Collaborative (PISEC) conducted numerous studies on learning in museum environments. In their first study, the collaborative confirmed that families actually learn in the museum environment, and they divided the learning into three levels: “Identifying”, “Describing”, and “Interpreting and Applying” (Borun, 1998). These levels were determined by key visitor behaviors: asking and answering questions, explaining and critiquing the exhibits, and reading text both aloud and silently (Borun, 1998). Further research by PISEC indicated that encouraging children and adults to interact and learn as a group increased overall learning, compared to going through an exhibit without interaction (Borun, 1998). PISEC also studied the long-term effects upon families that access museums and their programs. The collaborative determined the following seven characteristics of a family-friendly exhibit (Borun, 2013):

1. Allowing families to gather around the exhibit
2. Allowing families to participate simultaneously
3. Allowing comfortable exhibit use by both the children and adults in the family
4. Facilitating discussion by introducing complexity
5. Applying different learning styles and catering to different levels of knowledge
6. Arranging information into themes
7. Making connections

Many other studies and museums made similar points about the exhibit appealing to the visitor on a variety of levels. Lois Silverman, professor of Recreation and Park Administration at Indiana University, viewed the museum as an opportunity for families to be together, particularly

for interaction and learning (2010). According to Saul Carliner, professor of education and program director at Concordia University, emphasizing the importance of organizing complex topics into themes and layering information, as well as providing a fun factor by engaging various senses and helping the visitor make connections is critical (2001).

Every exhibit in a museum has a purpose. According to Leslie Bedford, professor of Museum Studies and consultant at the Museum Group, there are four main reasons an exhibit exists: it tells a story, educates viewers, broadens their imagination, or gives them a unique experience which they could not find elsewhere (2014). A narrative throughout the exhibit piques the visitor's interest (Carliner, 2001),

But what methods are available to create this experience? How does one determine which of today's technologies are most effective for an exhibit? According to George Hein, Professor Emeritus in the Graduate School of Arts and Social Sciences at Lesley University and Senior Research Associate with the Program Evaluation and Research Group at Endicott College, a museum has the responsibility of appealing to visitors on a variety of levels (1998). Different visitors have different learning styles, so different exhibit elements must correspond to different learning styles in order to appeal to the visitors' preferences (Simon, 2010). The different learning styles, according to George Hein, include *didactic*, *stimulus-response*, *discovery learning*, and *constructivism*. *Didactic learning* is the equivalent of traditional classroom learning. *Stimulus-response* is training the visitor to respond in an appropriate way to a particular provocation by rewarding appropriate behavior and penalizing inappropriate behavior. *Discovery learning* requires active participation and having experiences from exploring exhibits. *Constructivism* also requires active participation, but it is much more focused on connecting to the subject's prior knowledge and experiences through a wide range of learning methods (Hein,

1998). Thus, in order to fully engage its visitors, both the design of an exhibit and the technologies used within must create experiences for family members of all ages and learning styles. Now we had to understand the context of the Worcester Art Museum before we could explore the field ourselves.

2.6 THE WORCESTER ART MUSEUM

The Worcester Art Museum (WAM) is a mid-sized museum located in central Massachusetts. It has a “35,000-piece collection of paintings, sculpture, decorative arts, photography, prints, drawings and new media” spanning “fifty centuries of art” and it serves the Worcester community by providing a means for families or friends to gather (“Information”, n.d.). Established in 1896, it is one of the largest museums in New England.

The former Higgins Armory Museum (Higgins) in Worcester, Massachusetts had a strong record of attracting the family demographic. The Higgins was established in 1931 and, prior to its closing, had the second largest collection of arms and armor in the United States according to the Boston Globe (Gilsdorf, 2013) Their website featured creative and imaginative advertisements as well as presentations of their engaging and hands-on events. The Higgins held many events, usually partnering with smaller organizations which provided more focused expertise on a variety of subjects (Arning, 2009). The former Higgins Armory Museum evoked the time period through its banners and architecture, as you can see in Figure 2.3.



Figure 2.3: The interior of the former Higgins Armory Museum

In order to ensure that the collection remained in Worcester for public viewing and education, the Worcester Art Museum welcomed the massive Higgins collection in December 2013. In March 2014, a portion of the collection was displayed in the WAM's *Knights!* exhibit. The artifacts in the exhibit came from a wide variety of locations and time periods, not just medieval settings as the name implies. The exhibit had five separate sections — *Courtly Pursuits*, *The Dance of Love and War*, *Knights of the Round Table*, *Triumphal Arch*, and *The Corridor of Good + Evil* — that were meant to “illustrate in detail the historical context in which these works were made and used” (“*Knights!*”, n.d.). The original collection contained over 2,000 items and only a small number could be displayed at the WAM. The WAM Treasurer reported a “\$2 million increase in pledge receivables related to the Higgins integration” (Worcester Art Museum, 2013). From this collection, a team of WAM staff and Higgins Armory Museum's former director, Jeffrey Forgeng, are designing a more extensive and interactive medieval

exhibit, showcasing a greater number of the collection's artifacts (Worcester Art Museum, 2014; J. Forgeng, personal communication, February 10, 2016).

The WAM staff has conducted research to best implement the new exhibit. To further their work, Jeffrey Forgeng, the curator of Arms & Armor and Medieval Armor at the WAM, engaged a team of student researchers from WPI's Worcester Community Project Center to aid their design of this new exhibit. The team explored numerous implementations that would both attract and engage museum visitors in the Meyer Idea Lab, a temporary exhibit opening May 28, 2016 ("Jeppson Idea Lab: The Art of Combat", n.d.).

The WAM has some experience using digital technology to better engage visitors in the Knights! exhibit, which will close November 6, 2016 to make way for another temporary exhibit ("Knights!", n.d.). Most supplementary information was displayed through touch screen iPads. These devices allowed visitors to select items in the exhibit and read more detailed information. There was also a small room running an audiovisual movie about modern war. The rest of the displays featured "tombstone descriptions", or basic labels stating the item's name, place of origin, time period, and basic specifications (J. Forgeng, personal communication, February 10, 2016). As Jeffrey Forgeng explained, the layout was typical of an art museum: quiet and minimal. The design of the future medieval exhibit will begin by implementing more "object chat" presentation techniques to better engage visitors. These will take the forms of various technologies, some of which are being prototyped in the Meyer Idea Lab, a small and temporary medieval fencing exhibit on display from May 28, 2016 to September 4, 2016 ("Jeppson Idea Lab: The Art of Combat", n.d.).

Jeffrey Forgeng also stresses creating a sustainable exhibit. Simply piling additional technology and artifacts into a space may work for a short time, but would eventually bankrupt a

museum. An effective use of budget is a reason that some exhibits are able to stay popular for a long time, while others are neglected and forgotten about (Lang, Reeve & Woollard, 2006). Therefore, in collaboration with Jeffrey Forgeng, we aimed to provide recommendations for the upcoming exhibits at the WAM by balancing business goals, user goals, content and interaction.

The real question remained, which technologies best engage families and other visitors, and how can these be applied to the WAM? Museums around the world used a wide variety of technologies. From digital displays (ie. iPads) to audio tours, every museum expert has their own idea on the best approaches to using technology in exhibit design. These questions and more led us to explore the field, observe visitors in the galleries, survey visitor sentiment, and interview experts. We discuss our methodological approach in the following chapter.

3. METHODOLOGY

Our team investigated, developed, and recommended various technologies and exhibit design strategies to better engage families in the upcoming Meyer Idea Lab and Medieval Gallery at the Worcester Art Museum (WAM). In order to fully grasp the context of the Worcester Art Museum in light of other museums, we analyzed visitor demographics, the available educational media, visitor engagement with the media, and experts' perspectives on audience engagement. Additionally, we created a short film advertising swordplay and the upcoming medieval exhibits at the WAM in addition to an iPad application for the Meyer Idea Lab.

We achieved our overall project goal by following these six objectives:

1. Evaluated the current state of the Worcester Art Museum, particularly its arms and armor collection and its current implementation of iPads and other educational media.
2. Identified museums with engaging exhibits, especially those using iPads, and consulted their staff on implementation strategies.
3. Analyzed and evaluated success of engagement techniques from Objectives 1 and 2.
4. Designed and developed a personal promotional video of arms and armor at the WAM.
5. Designed and developed a digital media implementation for the iPads.
6. Provided recommendations for the Meyer Idea Lab and Medieval Gallery.

We discuss each objective in detail below.

OBJECTIVE 1: EVALUATED THE CURRENT STATE OF THE WAM, PARTICULARLY ITS ARMS AND ARMOR COLLECTION AND ITS CURRENT IMPLEMENTATION OF IPADS AND OTHER EDUCATIONAL MEDIA.

As of April 2016, the WAM began implementing some exhibit design components that would foster greater visitor engagement. They also tracked visitor demographics and opinions using surveys from November 2014 to February 2016. In order to understand the WAM's vision

for the arms and armor collection and the visitor's response to different museum media, we interviewed staff members, surveyed visitors, and conducted participant observation.

To begin our research, we interviewed eight staff members at the WAM ranging from the curator of the arms and armor exhibit to the gallery attendants. We interviewed Jeffrey Forgeng, curator of Arms and Armor and Medieval Art and additionally our project sponsor, in a semi-structured interview in order to learn his goals and better understand the scope of the project (see questions in Appendix A). We mostly used semi-structured interviews in order to guide the interviewee's response and to allow us the freedom of probing when we needed additional clarity or a response was of particular interest to us. When we had a spontaneous opportunity to meet with Adam Rozan, Director of Audience Engagement, we did not have prepared interview questions but we did seize the opportunity to speak to him about the best people to interview regarding success of museum interactives, museums worth investigating, and the visitors' expected outcomes from visiting an arms and armor exhibit.

In addition, we attended a meeting regarding the upcoming Idea Lab progress, where we heard about Katrina Stacy's role in developing the exhibit video of Jeffrey Forgeng's theme and Patrick Brown's role of constructing the exhibit casework. Following this meeting, we conducted additional semi-structured interviews with Katrina Stacy, Associate Curator of Education, and Marcia Lagerwey, Curator of Education, to better understand the intended interpretation of the Meyer Idea Lab and their perspectives on the role of art museums (see interview questions in Appendix B). We also briefly met with Tim Furman, Web Design Coordinator and Graphic Designer at the WAM, regarding our progress with the iPad implementation. Finally, we interviewed three of the WAM's gallery attendants using the interview questions in Appendix D

to gather their insight on visitor engagement from their daily observation of visitors to the exhibits: Robert Cardoza, Barin Bando, and Jorge Ramirez.

We reviewed the WAM's two recent surveys: the iPad survey of 869 people collected over the course of 16 months and the email survey of 544 people collected over 11 months. Casey Beaupre, the WAM's Visitor and Volunteer Services Manager, supplied both of these surveys, which spanned until the end of February 2016. After we evaluated the previously collected survey data, we orally surveyed visitors at the WAM regarding digital technology using the questions in Appendix G. Survey data was continually collected through the tablet displays being monitored in the Remastered Gallery and the Knights! exhibit. Surveys consisted of multiple choice and short answer responses. An analysis of visitor data was among the deliverables requested by our sponsor. In order to triangulate our research, we also observed visitors to compare their actions to visitors' survey responses.

We conducted participant observation in the Knights! and the Remastered exhibits on Friday, Saturday, and Sunday from noon until 2pm for two weeks at the WAM to better understand the educational media already being used in the WAM and how the visitors interacted with it. We selected one day with low visitation rates as the first day of observation to develop a system of note-taking followed by two days with the greatest visitation rates. During human observation, we documented the movement of visitors through the exhibit, primarily focusing on the duration and frequency of their interactions with the exhibit content and digital media, as well as their visiting profile which included gender, approximate age, and social context. The social context, as defined in the background, characterizes the kind and number of people who accompany the visitor as peers, family, and so on, as well as how this impacts their visit. The age

categories were baby, child, teen, young adult, middle aged, and senior. See Appendix F for our visitor observation notes.

OBJECTIVE 2: IDENTIFIED MUSEUMS WITH ENGAGING EXHIBITS, ESPECIALLY THOSE USING IPADS, AND CONSULTED THEIR STAFF ON IMPLEMENTATION STRATEGIES.

We conducted online research to identify museums comparable to the WAM either in target demographic (family audience), collection (arms and armor), size, or location (Worcester) which use successful engagement techniques. We also investigated museums noted for their engaging exhibits, particularly science and discovery museums, which were noted by staff at the WAM from our interactions in Objective 1. We contacted their educators or exhibit designers by email and followed up with a phone call. Next we scheduled an interview, if possible, and established a time to visit to observe the implementations and also observe how visitors interacted with the exhibit in order to analyze their success. We then visited neighboring museums with these characteristics to observe different aspects of their exhibits, and the ways in which they engage their visitors. Our focus was on successful and popular exhibits in the New England area so we could easily visit them in person, including the Boston Museum of Fine Arts, the Boston Museum of Science, the Worcester EcoTarium, the Worcester Historical Museum, deCordova Museum and Sculpture Park, and the Museum of Russian Icons. The other notable museums we contacted by phone interview included the USS Constitution Museum and the Peabody Essex Museum. We reached out to a number of large armories in Europe by email to ease the time difference and language barrier and to allow the museum staff to prepare their responses more fully, and the Musee de l'Armee in Paris and the Staatliche Kunstsammlungen in Dresden responded to our inquiries. Additionally, in the interest of time, we interviewed additional museum staff via email, including the Harvard Museum of Natural History, the

Harvard Museums of Science and Culture, the Isabella Stewart Gardner Museum, the Rhode Island School of Design Museum, the Philadelphia Museum of Art, the Discovery Museums, the Eric Carle Museum of Picture Book Art, the Walters Art Museum, and the Portland Art Museum. For the interviews that we did not conduct in person, we relied on digital tours when available and the accounts of their staff.

We primarily interviewed the museum staff involved in creating engaging exhibit design, including educators and exhibit designers. See the interview questions in Appendix C. In addition, we interviewed Stephen Bitgood via email, a retired professor at Jacksonville State University who has studied how psychology can be applied to exhibit design, for a more recent perspective on technology in museums.

While visiting museums, we paid particular attention to exhibits or materials making use of digital technology, especially iPads. We determined what the technology did as well as its contribution to the entire installation. We also noted whether the installation promoted involvement of both parents and children, whether the technology was intended as a focus or as a supplement, and whether the purpose could have been accomplished in another way. We asked the museums we contacted if they would be willing to share their visitor data, and we used that as another means of evaluating the success of their implementations.

The engagement success of the exhibit was then evaluated using the following criteria: participation rates from visitor observation, public sentiment gauged from reviews and survey data, and feedback from the staff we interviewed. In this way, our findings were validated by triangulation for it was supported by a variety of sources. In the following objective, we used these observations from the field as well as those from the WAM (Objective 1) to identify trends in our findings.

OBJECTIVE 3: ANALYZED AND EVALUATED SUCCESS OF ENGAGEMENT TECHNIQUES FROM OBJECTIVES 1 AND 2.

Using the data collected via interviews, surveys, and human observation in Objectives 1 and 2, we identified the strengths and weaknesses of various methods of engagement based on the following criteria: accessibility, sustainability, learning style, and visitor appeal.

After interviewing Marcia Lagerwey, we discovered that the WAM exhibit designers work together to address the accessibility of all parts of an exhibit for all of their visitors, so this criterion would be very important. For the Medieval Gallery, the WAM will work with an independent consultant regarding the accessibility of the exhibit.

Another feature that Jeffrey Forgeng and Tim Furman emphasized was sustainability. The WAM has limited funding, so all implementations must be successful at what they do and simultaneously withstand use. We also wanted the WAM to be able to continue using the implementations we established. This consideration was especially important for the iPad.

The learning style of an implementation was also very important, as outlined in our background. As Hein explained, learning style is an essential component in exhibit design, especially when it is targeted for a specific audience. It is important to incorporate different learning styles in an exhibit to address everyone's needs and make the exhibit even more accessible.

Visitor appeal was our final consideration, for we wanted something that the visitors would actually use. The success of visitor appeal was gauged based on our interviewee's perception of success, survey results, and human observation.

We created a comparative table using nine criteria to evaluate the engagement methods investigated in Objectives 1 and 2 (see Appendix E). These criteria included appeal to various learning styles, appeal to all ages, visitor reception, popularity, required maintenance,

implementation expenses, sanitation, safety, and relevance. We used this information to inform our production of a video in Objective 4 and an iPad implementation in Objective 5 and to provide recommendations for the future family-oriented arms and armor exhibits in Objective 6.

OBJECTIVE 4: DESIGNED AND DEVELOPED A PERSONAL PROMOTIONAL VIDEO OF ARMS AND ARMOR AT THE WAM.

We created a promotional video for the WAM to engage viewers in the arms and armor collection at the WAM, especially for the upcoming Meyer Idea Lab. We conducted extensive storyboarding and concept mapping with the assistance of Jeffrey Forgeng, who directed the concept and aim of the video. The first iteration involved a more formal and persuasive introduction to the Swordplay Workshop to improve attendance and overall community engagement with the WAM's programs about arms and armor. The second iteration placed more focus on the museum's proper exhibits such as Knights!, the Idea Lab, and upcoming Medieval Gallery, aiming to achieve the same goals of community engagement. For the third iteration, produced as a "director's cut" of the Idea Lab's in-house video on Joachim Meyer's history, our sponsor provided positive feedback on our content. He did request better quality narration (we used a quieter space and better audio recording/editing software for this) and for us to include our "personal touch" to the video so it was less formal. As a student-produced video rather than an official WAM video, we considered taking a unique approach. The final product juxtaposed historical content and the WAM's exhibitions with humor and wit for a memorable and unique perspective. It simultaneously promoted ongoing programs related to swords and swordplay at the WAM.

We began our video-producing process by discussing our concept with Jim Monaco. We discussed the original storyboard, and while the content of the video was significantly altered, many of the production techniques, such as Camtasia usage guidelines and scene organization,

we applied to later versions. From reading Jeffrey Forgeng's publications and viewing a previous research group's video on Joachim Meyer, we determined the historical content we wished to include in the video. We selected interesting and understandable facts to a wide audience that may not have any knowledge of sword fighting. Additionally, we avoided the content that would be presented in the Meyer Idea Lab so the visitor would want to watch the entirety once they entered the exhibit.

We gathered live footage for the video as well. We delivered most of the content through narration, so we used visuals to entertain and engage the viewer. Our sponsor gave us a hard drive full of archived Higgins content, previous video footage, and more recent documentation pertaining to the upcoming exhibits. We borrowed a high-quality video camera from the Academic Resources Center and used it to record Jeffrey Forgeng's choreographed fencing match in Institute Park in Worcester, Massachusetts. We used a similar camera with a tripod, under Jeffrey's supervision due to security protocol, in order to gather footage inside the WAM. Team members Anthony Ratte and Ian Converse recorded the narration using a Blue Yeti Microphone for suitable sound quality. We recorded audio and edited the video using Camtasia Studio.

OBJECTIVE 5: DESIGNED AND DEVELOPED A DIGITAL MEDIA IMPLEMENTATION FOR THE IPADS.

Using our findings from Objectives 1 through 3, we created an iPad app for the Meyer Idea Lab. The exhibit, opening May 28, 2016, showcases a fencing longsword and a medieval fencing manual with additional content provided on the iPad ("Jeppson Idea Lab: The Art of Combat", n.d.). The layout of the exhibit and the technology to be implemented were established by the WAM so we focused on designing the iPad content. We applied many of the design

principles found in our research, as well as advice from the exhibit design experts we interviewed in Objectives 1 and 2 to the iPad design.

We selected our implementation framework for the Meyer Idea Lab using the information Jeffrey Forgeng provided us about the desired content. When looking potential frameworks that would meet the needs of our sponsor, we examined a total of eight different options: Kiosk Pro, Unity, PhoneGap/Cordova, Ren'Py, LibGDX, OpenFL, Xcode, and Xamarin Platform (see Appendix I for details). One of the most important considerations when choosing a framework was compatibility with the Art of Combat fencing game. We also evaluated the frameworks on their ease of use and applicability to our project. For example, Ren'Py, while very easy to use, is more suited to creating interactive narratives and thus not applicable for our project. After evaluating the potential frameworks, we chose to design the iPad implementation in Unity. Unity allows the developer to easily lay out the scene and interface and test the implemented application without compiling and publishing the application to the iPad. It also allows the user to modify the interface while testing the application implementation.

Throughout the process of implementing the application, we remained in regular contact with Jeffrey Forgeng to provide input to the design process. Additionally, as the app was nearing completion, we submitted it through our sponsor for review by Tim Furman, Web Design Coordinator and Graphic Designer, and Katrina Stacey, Associate Curator of Education.

To help observe visitor usage of the iPad, we implemented software tracking so the WAM is able to see the duration spent by each user on a certain page. The feedback gathered from this small-scale exhibit would then be applicable to the Medieval Gallery and could be extended to the remaining galleries. In order to use the software tracking feature and be guided through more details of the iPad, refer to Appendix J.

OBJECTIVE 6: PROVIDED RECOMMENDATIONS FOR THE IDEA LAB AND MEDIEVAL GALLERY.

We considered combinations of engagement strategies that would complement each other before evaluating their feasibility and relevance in the context of the WAM. We then compiled this into a document summarizing our findings and providing recommendations to Jeffrey Forgeng for technological implementation in the Medieval Gallery. We broke down the document into general advice on the use of digital technology and specific analyses of different technological formats that could be used together.

We applied all of these objectives in order to realize our goal. In the next section, we discuss our findings.

4. FINDINGS

In this chapter, we discuss our findings on the effect of technology on museum visitor engagement. We begin by discussing the various roles of the art museum, according to expert sources, and how these roles affect exhibit design. We then examine the Worcester Art Museum's (WAM's) visitor base using survey data, our own participant observation, and oral surveys, before comparing it to regional data from New England Museum Association (NEMA) and to other museums we visited and interviewed. This progresses to our findings of engaging families using technology and exhibit design.

4.1 THE PURPOSE OF ART MUSEUMS

FINDING 1: MUSEUM CURATORS, EDUCATORS, GALLERY ATTENDANTS, AND VISITORS HAVE DIFFERING VIEWS ON THE ROLE OF THE ART MUSEUM.

The role of the art museum is subjective, and the perspective depends on who you ask. We found that their intimacy with exhibits led to strong biases with curators. The desire to promote learning also swayed many educators' opinions. Other museum staff and visitors had a variety of responses. However, beyond the obvious biases, we obtained interesting and inspiring answers from a number of experts. Surprisingly, a museum staff member's perspective did not necessarily correlate with the museum and department in which they work. Museum staff described the role of the museum as a place to preserve culture, a place to learn, and a place where people and communities can connect, but these roles do not always coincide with the visitor's expectations.

Preservation of Culture

According to many curators, historians, and museum staff, museums are responsible for the preservation of culture. Katrina Stacy, Worcester Art Museum Associate Curator of

Education, believes that the primary role of the art museum was preservation of culture for posterity (personal communication, April 4, 2016). According to the WAM's gallery attendant, Jorge Ramirez, an art museum "preserve[s] treasures from various cultures in the past that may otherwise wither away without special care" (personal communication, April 25, 2016). Both of these opinions were similar to the opinion of Worcester Historical Museum's Exhibit Coordinator, Vanessa Bumpus, who believes the role of the history museum included preservation and conservation (personal communication, March 23, 2016). Francis Henry Taylor, director of the WAM from 1931 to 1940 and then the MET until 1955, believed that art was a means of historical documentation defined by its context (1945), and according to historian and museum administrator Edward Alexander, a museum must take on preservation as one of its roles (1979).

Education

Other museum staff view education as the primary role of a museum. Jennifer Schmitt, deCordova Sculpture Park and Museum's Interim Head of Marketing and Head of Technology and Digital Engagement, believes that the art museum is primarily a place to learn, where people are able to think in ways that they do not usually think (personal communication, March 25, 2016). Similarly, Robert Cardoza, a gallery attendant at the WAM for the past ten years, believes that the primary role of the art museum is education (personal communication, April 19, 2016). At the Eric Carle Museum of Picture Book Art, Chief Curator Ellen Keiter noted that families and school groups visit particularly due to the museum's educational approach (personal communication, April 8, 2016). The Carle Museum's approach is governed by "picture books help[ing] to inspire a lifelong love of art and reading" ("Our Approach," n.d.). In 1972, 92% of museum directors found education to be very important (Alexander, 1979). According to Nina

Simon, Executive Director of the Santa Cruz Museum of Art & History and Lois Silverman, Professor in the Department of Recreation and Park Administration at Indiana University, art museums help facilitate learning (2010; 2010). According to the study of family conversations in art museums conducted by Karen Knutson et al. in 2011, they are also institutions of informal learning. Visitors surveyed in Britain by the Museums Association in 2013 indicated that providing public education is an important art museum function (Museums Association, 2013).

Connecting

Others believe that the role of art museums is to encourage visitors to make connections. Julie Bernson, Deputy Director for Learning and Engagement at deCordova Sculpture Park and Museum, believes that the art museum helps people connect art to their everyday lives (personal communication, March 25, 2016). Marcia Lagerwey, the Curator of Education at the Worcester Art Museum, reaffirmed this role, viewing the museum as a "powerful expression of humanity" (personal communication, April 11, 2016). In 2012, the Museum of Fine Arts investigated how museums can help visitors make connections; the MFA staff interviewed visitors who participated in either a trial multi-sensory tour or an ordinary tour, and found that visitors who participated in the multi-sensory tour remembered more details of their visit and made greater connections to their own lives (Dodek, 2012). WAM gallery attendant Jorge Ramirez believes that the art museum "present treasures to the world...to inspire others to create treasures of their own" (personal communication, April 25, 2016).

Fostering Community

The art museum unites communities. Marcia Lagerwey and Jennifer Schmitt both consider art museums to be important social institutions where communities are united (personal communication, April 11, 2016; personal communication, March 25, 2016). According to John

Cotton Dana, director of the Newark Museum from 1909 to 1929, art improves the community through the development of cultural pride and by appealing to ordinary visitors (1917). However, according to the 2013 survey of museums throughout Britain conducted by the Museums Association, this perspective was not shared by the majority of visitors. This illustrates a disconnect between visitors' and staff's perspectives.

Different Visions of the Roles of the Art Museum in Society

Additionally, there are more functions that visitors deem to be very important that were not mentioned by museum staff. According to a study performed by the Museums Association in 2013, visitors indicated the primary roles of the museum include attracting tourists and providing entertainment through happiness and well-being, in addition to the commonly accepted educational role (Museums Association, 2013). Benjamin Ives Gilman, Secretary of the Boston Museum of Fine Arts from 1893 to 1925, believed that art museums are meant to focus on promoting the visitor's experience of beauty, rather than tell a story (1923). This was contradictory to the views of Lynn Courtney and Vanessa Bumpus, who stressed the importance of storytelling in exhibits (personal communication, March 30, 2016; personal communication, March 25, 2016), potentially indicating the changing role of museums. In order to effectively engage a wide range of visitors and best draw from members of the staff, an art museum must serve several purposes.

4.2 VISITOR ATTENDANCE AT MUSEUMS

FINDING 2: ATTENDANCE RATES AT NEW ENGLAND MUSEUMS ARE INCREASING.

Contrary to our background research which indicated declining museum attendance, the data we analyzed showed increasing visitation rates. According to a study conducted by the National Endowment of the Arts, there was a 5% decrease in museum attendance between 2002

and 2012 (National Endowment for the Arts, 2012). Figure 4.1 illustrates the percentage of people in each age group that visited museums between 2002 and 2012. This research showed that every age group with the exception of seniors saw decreased visitation rates. Our research based on data from the WAM and other accredited museum through the New England Museum Association (NEMA) indicated otherwise. We found that attendance rates have increased in New England Museums.

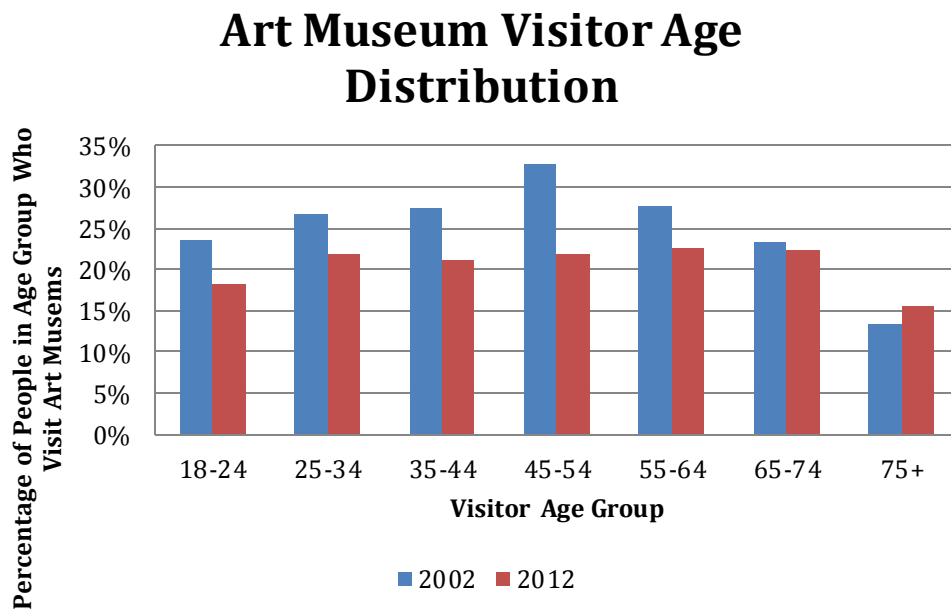


Figure 4. 1: Percentage of Art Museum Visitors in a Particular Age Group from 2002 and 2012 (<https://www.arts.gov/sites/default/files/2012-sppa-feb2015.pdf>)

We requested and received a 2015 Annual Report from NEMA, containing demographic information for 114 participating sites across New England. Records on general attendance from 2006 to 2015 showed that museum attendance at participating institutions increased (New England Museum Association, 2015). See Figure 4.2 for more details.

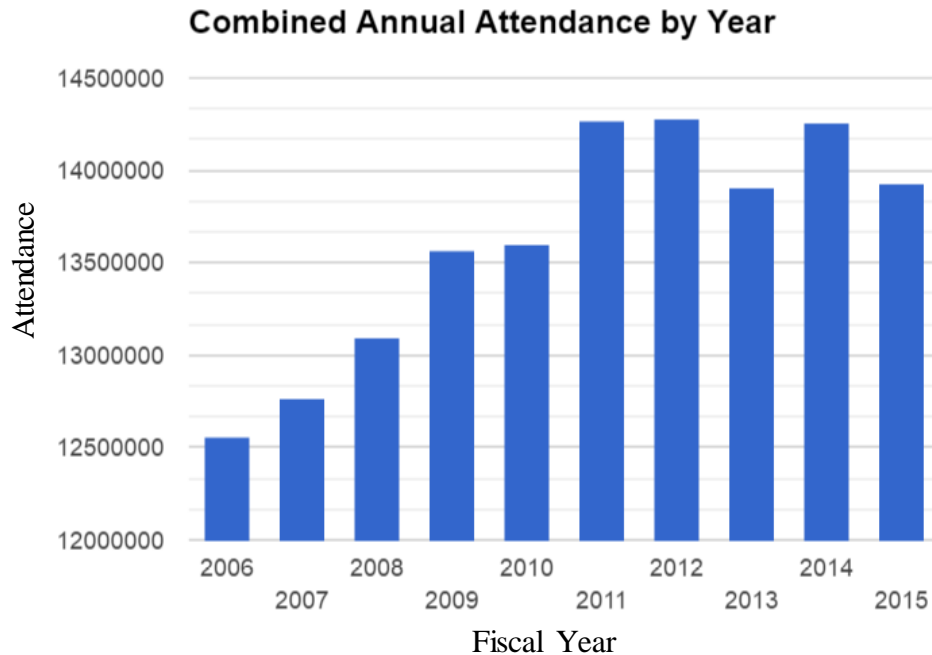


Figure 4. 2: Annual Attendance Rates
NEMA Stats: A Monthly Museum Attendance Report (Rep.). (2016).
Arlington, MA: New England Museum Association.

Exceptions did exist, however. Attendance rates in 2011 stabilized, and slightly decreased from 2014 to 2015. NEMA concluded that this recent drop in attendance is best explained by the historical snowstorms that hit the New England area during the winter of 2014 to 2015 (2015). School vacations typically experience higher visitation rates, according to the WAM’s Department of Audience Engagement (J. Frost, personal communication, April 12, 2016), but some museums recorded a record low at this time (New England Museum Association, 2015). Attendance to museums in Eastern Massachusetts was most significantly affected by large snowfall in a short amount of time that shut down public transportation and non-essential services, including the Massachusetts Bay Line Authority (MBTA) rail lines and taxi services, for multiple days in February and March (New England Museum Association, 2015). Overall, participating museums had an average attendance of just under 500,000 visitors in February of

2015. In comparison, these same museums reported attendance records of about 750,000 visitors in February of 2014 (New England Museum Association, 2015).

The significant decline in attendance during February 2015 can best be seen in Figure 4.3, showing the combined monthly attendance compared to previous years. Note that the attendance numbers for 2015 are comparable to other years, except for the month of February where attendance was at an all-time low (New England Museum Association, 2015).

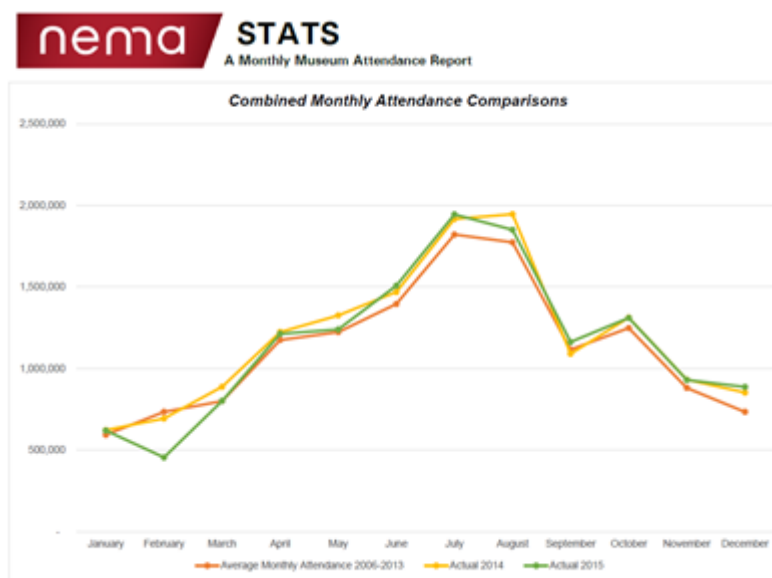


Figure 2

Figure 4. 3: Monthly Museum Attendance Comparison
NEMA Stats: A Monthly Museum Attendance Report (Rep.). (2015).
Arlington, MA: New England Museum Association.

Similarly to the attendance rates across New England increasing, from 2011 to 2013, the attendance rates at the WAM have also been increasing. The free attendance has been increasing most substantially, but with time, the paid admission has also been increasing. See Figure 4.4.

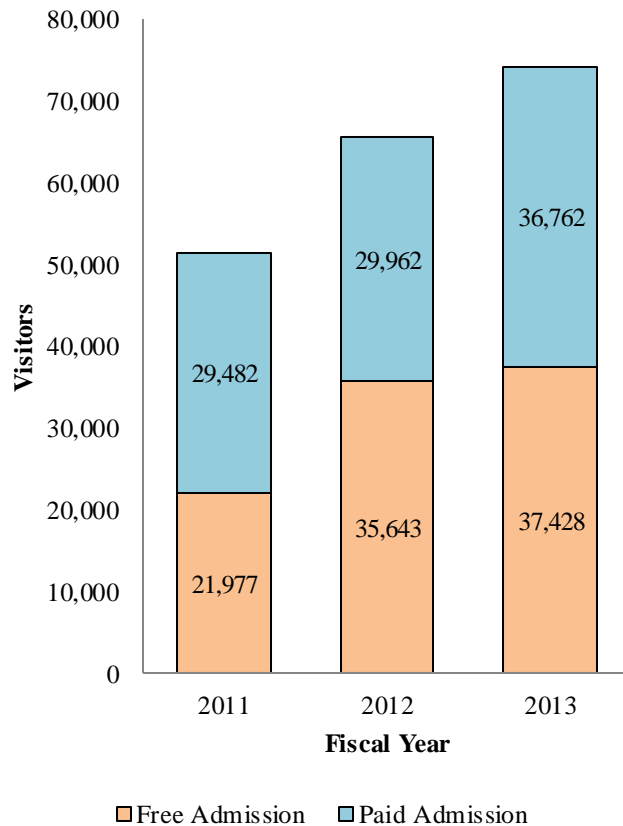


Figure 4. 4: Annual Attendance to the Worcester Art Museum (Worcester Art Museum, 2013)

FINDING 3: THE OBSERVED DEMOGRAPHICS AND TARGET AUDIENCE OF MUSEUMS USUALLY DO NOT COINCIDE.

In addition to overall attendance, we evaluated demographic data from the WAM and compared it to various museums such as the NEMA collection. Often, there was a disconnect between a museum’s stated target audience and the primary audience visiting that museum or exhibit. Museum staff at deCordova Sculpture Park and Museum, the Philadelphia Museum of Art, the Museum of Russian Icons, the Worcester Historical Museum, and the Portland Art Museum identified everyone as their overall target museum audience (J. Bernson & J. Schmitt, personal communication, March 25, 2016; E. Baill, personal communication, April 6, 2016; J. Dolan, personal communication, March 23, 2016). The Harvard Museums of Science and

Culture similarly targeted all ages (J. Sacco, personal communication, March 28, 2016). In order to appeal to a variety of people, exhibits target different audiences with their collection and design, as was the case at the Walters Art Museum, the Boston Museum of Fine Arts, the Philadelphia Museum of Art, the Peabody Essex Museum, the WAM, and deCordova Sculpture Park and Museum (A. Kodeck, personal communication, April 4, 2016; L. Courtney & B. Martin, personal communication, March 30, 2016; E. Baill, personal communication, April 6, 2016; E. Rodley, personal communication, April 11, 2016; J. Forgeng, personal communication, February 10, 2016; J. Bernson & J. Schmitt, personal communication, March 25, 2016). This requires exhibits to be designed with a certain audience in mind.

Targeting Audiences Through Exhibit Design

Many museums, particularly science museums, target families and children and design their exhibits to appeal to that audience. These audiences correspond to the target audience of the arms and armor collection at the WAM (J. Forgeng, February 10, 2016). The Boston Museum of Science encouraged visitors to participate by providing clear instructions and posing questions for the visitor to answer and discuss among their group, especially in the *Seeing is Deceiving* exhibit where their observations could be much different than those of their companions (observation, March 30, 2016). The exhibits of the EcoTarium and Discovery Museums are similarly designed to be interactive, appealing to families and children (B. Loring, personal communication, March 23, 2016; C. Lonardo-Roy, personal communication, March 23, 2016). Visitors to the EcoTarium are mostly parents with children under twelve years old (B. Loring, personal communication, March 23, 2016). The Eric Carle Museum of Picture Book Art primarily attracts families and school groups and as such, they target this group in their marketing and exhibit design (E. Keiter, personal communication, April 8, 2016). The USS

Constitution Museum also targets families and intergenerational visitors by applying findings from the Philadelphia Informal Science Education Collaborative (PISEC), integrating different learning styles in their exhibits, and using interactives to convey themes (R. Kiihne, personal communication, April 8, 2016; USS Constitution Museum, 2013).

Disconnect between Target Audience and Average Visitor

The target audience and the actual visitor base do not always coincide. At the Museum of Fine Arts, where the target audience changed depending on the exhibit, the average visitor was an older woman with a graduate degree and a high household income; 85% of their visitors hold at least a graduate degree (B. Martin, personal communication, March 30, 2016). The Peabody Essex Museum also reported that their target audience varied by exhibit, and yet their demographic was very similar albeit even more specific: the typical visitor was a 57 year old Caucasian woman with a graduate degree and a high socio-economic status (E. Keiter, personal communication, April 8, 2016). The Harvard Museums of Science and Culture also had a predominantly white, upper middle class, educated average visitor, while also being significantly popular among tourists and school groups (J. Sacco, personal communication, March 28, 2016). These demographics coincided with the literature, where art museums were viewed as elitist and exclusive (Alexander, 1979; Carliner, 2001; Woodson-Boulton, 2012).

Family Activities in Art Museums

A less typical approach was for art museums to incorporate the family communication dynamic into their family activities, which usually were designed just for kids below a certain age and alienated the rest of the family. At the Peabody Essex Museum, Educator-in-Residence Marianna Adams investigated the experience of families in the museum and recorded her observations on her blog in the summer of 2014: she observed that family programs usually

place all of the children in a circle on the floor and the parents would stand around but away from them, inhibiting interactions between family members (Adams, 2014). This resembled the findings of Knutson et al., where the family art studio should have equal accessibility for both children and adults, such as two sizes of art easel for the adult and for the child, in order to invite creativity, interaction, and collaboration across generations (2011). Some museums alter their exhibit design in order to appeal to different audiences. At the Museum of Russian Icons, the overwhelming majority of visitors were the elderly, but the young family demographic was growing due to the introduction of various design elements that stimulate family interaction, such as ambient sound, audio wands, rest areas, and interactives (L. Garrity-Arquitt, personal communication, April 6, 2016). Tailoring exhibits to encourage family dynamics incorporated a variety of factors determined by a study from PISEC, and determined a list of family friendly traits: multi-sided, multi-user, accessible, multi-outcome, multi-modal, readable, and relevant (Borun, 2013).

FINDING 4: SIMILAR TO MOST NEW ENGLAND MUSEUMS, THE WAM'S KNIGHTS! EXHIBIT'S ACTUAL DEMOGRAPHICS DO NOT ACCURATELY REFLECT THE TARGET AUDIENCE.

According to the arms and armor curator, Jeffrey Forgeng, the target audience of the arms and armor collection is the family audience (personal communication, February 10, 2016). In a museum, the family audience is typically comprised of parents and children under the age of thirteen (A. Poterack, personal communication, April 15, 2016). WAM survey data and our visitor observation revealed that groups of two were the primary visitors to the Knights! exhibit, although Knights! did have a great deal more young children than Remastered (observation, April, 2016).

Based on the observation of 141 visitors conducted over three consecutive days (Friday April 8, 2016; Saturday April 9, 2016; Sunday April 10, 2016) from noon to 2pm, 8% of the visitors in the Knights! exhibit were seniors, 50% were middle-aged, and another 24% were young adults (observation, April 8-10, 2016). Most of the visitors came in pairs, with a friend or significant other of about the same age, so the gender distribution was split evenly. At the same time, visitor observation was conducted in the Remastered Gallery. In Remastered, a gallery displaying paintings in a more conventional setting, we observed a total of 130 visitors, of which 21% were seniors, 46% were middle-aged, and 19% were young adults (observation, April 8-10, 2016).

Compared to Remastered, the Knights! exhibit is much more popular among young children. In the Remastered Gallery, of the 130 visitors, 6% were children and 8% were teenagers (observation, April 8-10, 2016). Of the 141 visitors to the Knights! exhibit, 12% were children and 7% were teenagers (observation, April 8-10, 2016), indicating that the exhibit is more popular among young children. Note the difference in visitors' age groups we observed in Figure 4.5.

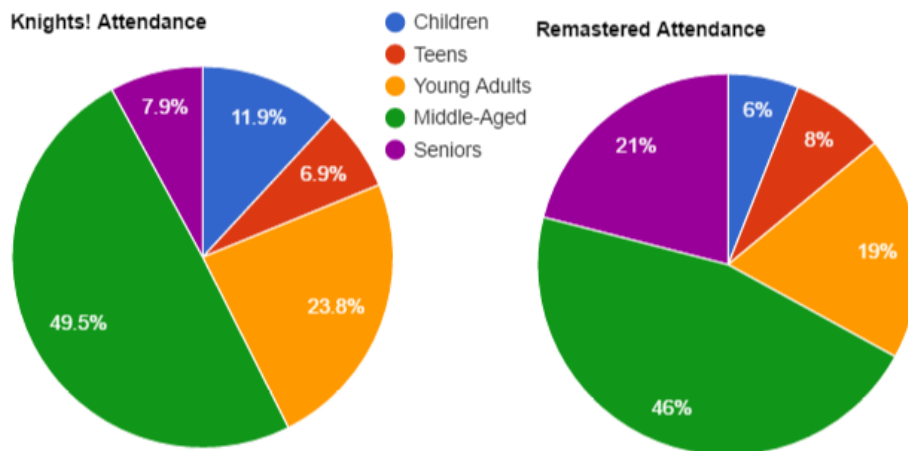


Figure 4. 5: Comparison of Visitors' Approximate Ages in the Knights! exhibit and Remastered

We also observed in the Knights! exhibit during the week of April vacation for many Massachusetts public schools. We observed 153 visitors over three consecutive days (Wednesday April 20, 2016; Thursday April 21, 2016; Friday April 22, 2016) from noon to 2pm. Compared to normal, non-school vacation weeks, we saw a significant increase in the number of children and teens and a decrease in many other age groups (observation, April 20-22, 2016). Children accounted for 28% of visitors while teens accounted for 17% of total visitors compared to 11% and 7% of total visitors respectively for normal weeks (observation, April 20-22, 2016). On the contrary, middle aged and young adults saw the largest decrease in visitation rates with only 29% middle aged visitors and 9% young adult visitors compared to 50% and 24% respectively during normal weeks (observation, April 20-22, 2016). This shows that as expected, children and teens are more apt to visit museums during school vacation weeks.

4.3 EFFECT OF TECHNOLOGY ON VISITOR ENGAGEMENT IN MUSEUMS

Technology in a museum can take many forms and can be used in a variety of ways. Oftentimes, the use of technology is beneficial to the visitor's experience, but its effect ultimately depends on its implementation. If used inappropriately, technology can detract from the visitor experience or have no effect, wasting time and resources. We analyzed the general trends of the effect of technology on visitor engagement using interviews, surveys, and participant observation. Below we investigate three possible outcomes of technology in an exhibit: positive, negative, and ineffective.

FINDING 5: TECHNOLOGY IMPROVED THE VISITOR EXPERIENCE.

In every museum we explored, we witnessed technology being used to provide a memorable and enjoyable experience for visitors. This was done in a variety of ways. First, technology helped make visits personal. Second, technology helped overcome communication

barriers for greater accessibility. Third, technology catered to the desires and expectations of a modern audience. Fourth, technology allowed visitors to better enjoy the details of displayed objects. Finally, technology allowed museums to target specific audiences.

Technology can personalize visits.

Technology can be utilized in several ways to connect the lives of visitors with exhibits. The first way allowed visitors to take ownership of some part of the museum. Many museums encouraged visitors to create something. The Museum of Russian Icons and Boston Museum of Science provided supplies for visitors to make crafts and drawings they could then take home (L. Garrity-Arquitt, personal communication, April 6, 2016; observation, March 30, 2016). Similarly, the Museum of Fine Arts (MFA) in Boston used a digital tablet to allow visitors to design a textile or plate and email their creation to themselves. Visitors requested the ability to email creations on surveys which the museum then added (L. Courtney, personal communication, March 30, 2016). In a similar vein, the EcoTarium provides blocks for visitors to build structures and view them on an infrared camera. Betsy Loring, Director of Exhibits for the Worcester, Massachusetts based science museum, said that exhibits like this could entertain visitors for up to twenty minutes, “an eternity” at a museum (personal communication, March 23, 2016). At the deCordova Sculpture Park and Museum, the museum invites visitors to collaboratively create artwork for other visitors to see and later interact with, such as the drawing with water interactive in Figure 4.6 where a visitor painted a smile within a circle already on the wall (observation, March 25, 2016).



Figure 4. 6: Drawing with Water Interactive at deCordova Museum

Many museums encourage the creation and sharing of thoughts. The MFA allowed visitors to post to Twitter directly from a display in the Textiles exhibit (L. Courtney, personal communication, March 30, 2016). Similarly, the Portland Art Museum encourages the use of Twitter hashtags at multiple exhibits such as #nwonoggin (an exhibit with pipe-cleaner neurons) to facilitate online discussion and prompt visitors with questions (J. Dolan, personal communication, March 23, 2016). We observed that all museums allow photography, the most obvious way of owning a trip. The Worcester Historical Museum even provides selfie stations and a green screen, which are heavily used according to Exhibit Designer Vanessa Bumpus (personal communication, March 23, 2016). In the lobby of the WAM, we observed several school groups taking photographs in front of the murals, prompted only by the footprints on the floor (observation, April 13, 2016). Claudia Schmidt from the Staatliche Kunstsammlungen Dresden described a downloadable smartphone app used by her museum called “Artomat” which allowed visitors to create their own photo gallery with automatic data entry from image

recognition (personal communication, March 23, 2016). Finally, Ms. Bumpus and others reminded us that visitors like to take pamphlets and guides home with them (personal communication, March 23, 2016).

The second way that technology makes visits personal is through helping visitors make connections between what they learned in the museum and their own lives. Storytelling is a common way of personalizing a visit. At the Museum of Russian Icons, Registrar Laura Garrity-Arquitt informed us that they frequently “built exhibits around stories” (personal communication, April 6, 2016). In science museums this personal connection can be formed by connecting phenomena such as electricity to daily life. For example, the EcoTarium allows visitors to generate static electricity and animatronic displays reenacted the dangers of electricity (observation, March 23, 2016). The Boston Museum of Science holds a lightning show with familiar stories such as Benjamin Franklin’s kite and a demonstrator dispelling the common myth that the rubber tires on cars insulate from lightning strikes (observation, March 23, 2016). The MFA make connections between historic room recreations and modernity through tablets that allow visitors to compare the original prices of historical items to more familiar objects like a couch or chair (observation, March 30, 2016). Exhibits at the Portland Art Museum and the deCordova Sculpture Park and Museum connected visitors with more local issues and stories such as the personal stories of students and area conservation efforts (J. Dolan, personal communication, March 23, 2016; J. Bernson, personal communication, March 25, 2016). A second smartphone app from the Staatliche Kunstsammlungen Dresden, called Kunstcaching (German, literal translation: art caching), helped visitors find art around the city of Dresden (C. Schmidt, personal communication, March 23, 2016). The data we analyzed from earlier WAM surveys pointed to a desire for more context like this in the Knights! exhibit.

Technology can improve communication.

In literature, through interviews, and during visits we witnessed many examples of technology being used to overcome barriers of language and disability (Srinivasan, Becvar, Boast & Enot, 2010). Staff from seven museums expressly mentioned language accessibility through labels, audio, and sometimes even video. The Peabody Essex Museum offers English and Spanish on labels and in digital publications for their *Alchemy of the Soul* exhibit (E. Rodley, personal communication, April 25, 2016). The Museum of Russian Icons provides an impressive five languages on their audio tours: English, Russian, Portuguese, and French (L. Garrity-Arquitt, personal communication, April 6, 2016), while the Musée de l'Armée in France provides eight: French, English, German, Italian, Spanish, Russian, Chinese, and Japanese (S. Picolet, personal communication, March 31, 2016). The choice in languages offered by museums is generally based on the expected visitor base. The two museums closest to the WAM, the EcoTarium and the Worcester Historical Museum, both offered Spanish through labels and video (B. Loring, personal communication, March 23, 2016; V. Bumpus, personal communication, March 23, 2016). Ed Rodley, the Associate Director of Integrated Media at the Peabody Essex Museum, pointed out that subtitles and labels, even in English, help non-native speakers, because many can read a language prior to understanding it when it is spoken (personal communication, April 11, 2016).

Additionally, technology can assist the hearing or visually-impaired. Every museum we investigated used labels, which allow the hearing-impaired to easily access information. Ellen Keiter, Chief Curator of the Eric Carle Museum of Picture Book Art said her museum even provides scripts of audio tours for those unable to comfortably listen to them (personal communication, April 8, 2016). Furthermore, audio tours provide a way for many museums to service the visually-impaired. In the Museum of Russian Icons, personal devices provided

enlarged text in addition to audio tours (L. Garrity-Arquitt, personal communication, April 6, 2016). Finally, the staff at four museums mentioned the Americans with Disabilities Act (ADA) requirements, with one expert calling them a “low bar” that can be easily improved through technology (L. Garrity-Arquitt, personal communication, April 6, 2016).

Technology can be used to present information in an appealing way.

Technology provides a variety of mediums to present information to visitors in an appealing way. It can simultaneously cater to various learning styles and provide a multi-sensory experience. We observed sight, sound, touch, and even smell being used in museums. Joshua Helmer, Assistant Director for Interpretation at the Philadelphia Museum of Art, described the benefit of increased attendance by taking a “multi-avenue” approach (personal communication, April 4, 2016), while literary sources refer to the need for a “multisensory” approach to better engage visitors (Price, 2014; Hein, 1998). The deCordova Sculpture Park and Museum used four or more technologies in large exhibits (observation, March 25, 2016). Approximately half of all museums we examined used tablets to varying degrees, and even more used some kind of video setup. Janis Sacco, Director of Exhibitions at the Harvard Museums of Science and Culture and Julie Bernson at the deCordova Sculpture Park and Museum stressed the necessity of having something for visitors, both adults and children, to touch (personal communication, March 28, 2016; personal communication, March 25, 2016). Lynn Courtney, Head of Planning and Evaluation at the MFA, showed us examples where changing technologies between exhibits helped provide a fresh experience. The MFA's Behind the Scenes exhibit provides games and videos with seating as a respite from browsing galleries (personal communication, March 30, 2016). Others, such as Robert Kiihne, Director of Exhibits at the USS Constitution Museum,

discussed the use of games to provide another method of interaction (personal communication, April 8, 2016).

In addition to providing various mediums of communication, technology also allows for interesting and varied delivery systems. Labels and stationary devices are still the most widely used way of providing information to visitors at an object (Borun & Dritsas, 1997), but many visitors also like how handheld systems deliver information directly to the user (Falk & Dierking, 2008). Approximately one third of museums surveyed mentioned some kind of beacon, image recognition, or number activated system for calling up portable media such as text, pictures, or video. The MFA experimented with implementing all three, but found the beacons to be lacking in precision in closer-packed exhibits (L. Courtney, personal communication, March 30, 2016). One study showed that 91% of visitors enjoy information delivery systems such as beacons (Zimmerman & Lorenz, 2008) and another study by the Smithsonian showed that automated guide systems are used much more consistently by visitors than printed guides (Bitgood, 2013).

Technology can help visitors to appreciate detail.

In addition to delivering information in an appealing manner, technology can tie that information in with the items on display. By directing attention and pointing out detail, several museums increased visitor appreciation and interest in exhibits. Studies in the Peabody Essex Museum, Franklin Museum, Frye Art Museum, Brookfield Zoo, Anniston Museum of Natural History, and Chicago Botanic Gardens showed that regardless of the form used, guides significantly increased the time spent in exhibits, as well as improved learning and recall (Bitgood, 2013). According to a research team at the National Museum of Natural History in Taipei, 40% of visitors noticed more detail with electronic guides (Sung, Chang, Hou & Chen,

2010). The MFA and Museum of Russian Icons used magnifying glasses to assist visitors with appreciating the detail of the artwork (observation, March 30, 2016; observation, April 6, 2016). In one notable example, the MFA used a tablet to chronicle the story of the Trojan War by directing the visitor's attention to events portrayed on a Grecian Urn (L. Courtney, personal communication, March 30, 2016). A similar device in the Tapestry Room of the Isabella Stewart Gardner Museum allows visitors to zoom in on details of tapestries (M. Grohe, personal communication, April 4, 2016).

Technology allows museums to target specific audiences.

Most museum curators design exhibits to target a specific audience. A group commonly targeted, and the focus of this project, is the family audience. At the Peabody Essex Museum, Ed Rodley said that labels were tailored to various age groups and levels of expertise, albeit with much overlap (personal communication, April 11, 2016), while Janis Sacco of the Harvard Museums of Science and Culture said that labels were written at roughly a middle school reading level for broader accessibility (personal communication, March 28, 2016). Furthermore, experts cited the dynamic of a family and their interpersonal interactions as highly important. Staff at the MFA and Harvard Museums of Science and Culture, along with researcher Stephen Bitgood agreed that in many cases, exhibits should allow adults to help children interpret information, rather than directly targeting children (L. Courtney, personal communication, March 30, 2016; J. Sacco, personal communication, March 28, 2016; personal communication, March 18, 2016). At the Discovery Museums and Philadelphia Museum of Art, this led to systems where, in the words of Cara Leonardo-Roy, Director of Visitor Experiences, "Children lead, and adults follow" (personal communication, March 15, 2016). The Philadelphia Museum of Art implemented their first app for families, *A is for Art Museum*, on a durable tablet device to encourage parents to let

children direct the experience (J. Helmer, personal communication, April 4, 2016). In a survey of 4000 visitors, 50% rated the app “superior” and 38% rated it “excellent,” with 30% of families engaged in activities at all 26 works of art (J. Helmer, personal communication, March 15, 2016). At the USS Constitution Museum groups and families are encouraged to interact through games and by providing larger displays rather than tablets (R. Kühne, personal communication, April 8, 2016). For the same reason, microscopes at the EcoTarium were connected to large screens instead of individual eyepieces (B. Loring, personal communication, March 23). Studies by the Eric Carle Museum of Picture Book Art, consisting of surveys and interviews, showed that 80% of parent visitors wished for more interactive experiences for their children in the galleries. As a result of these findings, the museum created family activity kits, scavenger hunts, activity sheets, and continue to brainstorm ways to engage families when planning upcoming exhibitions (E. Keiter, personal communication, April 8, 2016).

FINDING 6: TECHNOLOGY CAN DETRACT FROM THE VISITOR EXPERIENCE.

For all the benefits technology can provide, it can just as easily detract from the visitor experience. In interviews, many experts warned that in addition to ruining aesthetics and wasting space, technology can easily become distracting if not used correctly. For families in particular, this was seen as a significant drawback due to disruption to the family dynamic.

Experts at the MFA, Peabody Essex Museum, and Worcester Historical Museum stressed the necessity of integrating technology into an exhibit in a visually appealing way to avoid ruining the aesthetic and to place visual displays close to objects to avoid competition for visitor attention (L. Courtney, personal communication, March 30; E. Rodley, personal communication, April 11, 2016; B. Loring, personal communication, April 25, 2016). Furthermore, a case study at the National Museum of History in Taipei shows that digital technology's competition for

attention can reduce learning outcomes among museum goers (Sung et al., 2010). For this same reason, many experts recommended keeping flashy displays to a minimum (Bitgood, 2013; Orfan, Lundgren, Harrington & Becan, 2014). Ed Rodley claimed that the Peabody Essex Museum avoids using visual displays when designers want visitors to focus on the artwork (personal communication, April 11, 2016). Others, such as the Philadelphia Museum of Art, specifically designed their handheld devices to direct visitors back to the physical objects (J. Helmer, personal communication, March 15, 2016), a method also used in the Hunt Museum (Hall & Bannon, 2005).

But even with these considerations, several experts warned that tablets and screens can still be distracting in family oriented museums. Betsy Loring told us that children in particular were prone to playing with tablets, rather than using them as intended (personal communication, March 25, 2016). In the Boston Museum of Science, we observed children aimlessly pressing buttons and transitioning between screens with no focus on objects, regardless of the presence of a parent (observation, March 30, 2016). Ms. Loring informed us that parents bring children to museums to get them away from technology and that they want their children to see the exhibits, “not the screens” (B. Loring, personal communication, March 25, 2016).

In addition to visual distractions, some experts discussed audio distractions. At the MFA, Lynn Courtney and Barbara Martin shared that audio playback was sometimes choreographed to prevent sound bleed. Additionally, handheld devices with audio have the potential to bother nearby visitors, so the MFA began selling headphones to prevent this happening with their audio tours (personal communication, March 30, 2016). The Museum of Russian Icons, which used audio wands, which are handheld, self-contained audio players, for audio tours, played ambient

music that covered up the noise from the audio wands and encouraged conversation (L. Garrity-Arquitt, personal communication, April 6, 2016; observation, April 6, 2016).

FINDING 7: SOME IMPLEMENTATIONS OF TECHNOLOGY HAVE NO EFFECT ON VISITOR ENGAGEMENT.

In some cases, technology may not detract from the visitor experience, but it also fails to further engage the visitor. We formed three categories in which to explore these phenomena. In the first, we found that visitors did not pick up guides. In the second, we found that visitors ignored content that did not seem easily accessible. In the third, we found digital technology used in situations where it provided no advantage over traditional media for engaging visitors.

First we examined the use of guides. Studies at the Anniston Museum of Natural History and the Denver Art Museum showed that most visitors do not pick up guides: only 2% of visitors entered the observed exhibit with guides, when guides were not directly handed out (Bitgood, 2013). This was also the case with audio guides at the MFA, which had low usage rates with only 4-5% for general use and approximately 25% for special exhibitions (L. Courtney, personal communication, March 30, 2016). The only museum where any form of guide was used by the majority of visitors was the Museum of Russian Icons, where the museum staff directly offered free audio wands to visitors upon entry (L. Garrity-Arquitt, personal communication, April 6, 2016).

Additionally, we learned that visitors often ignore technology when the display does not seem accessible in content, length, and wording. Betsy Loring encouraged designing exhibits using “inquiry based learning” and “visual thinking”, where visitors would ask questions, make predictions, and test them (personal communication, March 25, 2016). Additionally, esoteric language was mentioned on three occasions as another deterrent to use (B. Loring, personal communication, March 25, 2016; L. Courtney, personal communication, March 30, 2016; L.

Garrity-Arquitt, personal communication, April 6, 2016). Length also played an important role. Lynn Courtney claimed that visitors generally do not read long-form text, choosing rather to browse, but that they can still gain impressive insight (personal communication, March 30, 2016). Vanessa Bumpus similarly recommended keeping labels to a maximum of 250 words (personal communication, March 25, 2016), while Laura Garrity-Arquitt used a one-minute reading time as a rule of thumb (personal communication, April 6, 2016).

Finally, unnecessary use of digital technology was reported by experts to provide no benefit to visitor engagement over traditional media. When determining whether digital media will better engage visitors, Barbara Martin of the MFA and many others recommended first considering “what can this technology do that can’t be done otherwise” (personal communication, March 30, 2016). Additionally, Stephen Bitgood reminded us that digital technology is “not a substitute for sound thinking and design,” and that “low tech devices such as flip labels, when used intelligently, can engage visitors as well as any high tech devices” especially because some visitors may not be comfortable using technology (personal communication, March 18, 2016).

Furthermore, preventing visitors from ignoring digital technology requires additional effort. Traditional media, such as labels still serve as the primary way for visitors to interact with exhibits (Borun & Dritsas, 1997; B. Martin, personal communication, March 30, 2016), and surveys in the Knights! exhibit indicated that 83.4% of visitors willing to fill out iPad surveys read the exhibit's labels. Visitors, however, saw tablets as less accessible with only 8-10% using them in the WAM exhibits observed (See Finding 11). Exhibit designers at the MFA used “touch to begin” messages along with consistent easy-to-use interfaces, identified during prototype studies when first implementing touch screen technology (G. Scharoun, personal

communication, March 30, 2016). They found other technologies such as QR codes too inaccessible (L. Courtney, personal communication, March 30, 2016; Fite, Feeney & Baulier, 2013; Falk & Dierking, 2008) and were only observed regularly in deCordova Sculpture Park and Museum as a delivery method for artist commentary (observation, April, 2016). But even if digital technology can be made as accessible as traditional media, it does not necessarily provide any benefit to visitor engagement, and some visitors will ignore it regardless (L. Courtney, personal communication, March 30, 2016).

FINDING 8: MOST MUSEUMS USE SIMILAR TECHNIQUES FOR THE DEVELOPMENT OF TECHNOLOGY.

In our interviews with museum staff, we found that most museums used similar techniques for developing technology. Development involved a combination of in-house and contractor work and collaboration among experts in various fields. Most museums choose to focus on human observation or public surveys over public consultation. This helped inform the highly iterative process of exhibit creation and the technology included within.

There was little correlation between museum size and whether the museum developed the exhibit technology in-house or contracted out. We were unable to develop a dichotomy between the two cases, because when outside companies were brought in, such as at the MFA, they worked closely with staff (L. Courtney, personal communication, March 30, 2016). Other times, when much of the work was done in-house, people outside the museum still needed to be hired. For example, staff at the Museum of Russian Icons wrote the audio tours, but a voice actor recorded the narration (L. Garrity-Arquitt, personal communication, April 6, 2016). In most cases, creation of content required both internal and external efforts. Additionally, two museums mentioned the use of content management systems (CMS's) to retain some control over the technology after developers had left (L. Courtney, personal communication, March 30, 2016; J.

Helmer, personal communication, April 4, 2016), and all museums with digital devices obtained them from a third party (personal communications, March-April, 2016).

Several experts deemed collaboration between different departments in the museum important. At the Eric Carle Museum of Picture Book Art, the Education, Curatorial, Development, and Guest Services departments collaborated to design exhibits (E. Keiter, April 8, 2016). Staff at the EcoTarium, Worcester Historical Museum, MFA, Harvard Museums of Science & Culture, and WAM expressed the importance of having content experts to provide accurate information, as well as interpretive experts to present this information clearly to the public (B. Loring, personal communication, March 25, 2016; V. Bumpus, personal communication, March 25, 2016; L. Courtney, personal communication, March 30, 2016; J. Sacco, personal communication, March 28, 2016; J. Forgeng, personal communication, March 26, 2016). A common trend we observed was that curators are too eager to present information, not realizing that visitors might skim the information to leave time for other exhibits, or because they have lost interest (B. Loring, personal communication, March 25, 2016; V. Bumpus, personal communication, March 25, 2016; L. Courtney, personal communication, March 30, 2016).

In forming the balance between context and accessibility, museum staff used visitor observation and some surveys. Surveys were not heavily used, however, because visitors have a habit of “over-reporting” technology use (L. Courtney, personal communication, March 30, 2016) and are bad at predicting what they would enjoy in future exhibits (B. Loring, personal communication, March 25, 2016). This was the case in several museums, and in a previous study conducted in the WAM's Knights! exhibit, 54% of visitors reported using tablets in a survey conducted on an iPad, a possible cause for the discrepancy, but we observed only 9% of visitors

used the iPads in the Knights! and Remastered exhibits (Worcester Art Museum, 2016; observation, April 8-10). Additionally, visitors reported feeling disgruntled by the deliberate lack of labels in the WAM's Remastered Gallery, but another team of researchers observed increased engagement with the iPads and longer amounts of linger time in the gallery (J. Forgeng, personal communication, March 26, 2016). To address this problem, museums like the MFA and USS Constitution Museum used software to directly track visitor interactions with digital devices and remove any uncertainty (L. Courtney, personal communication, March 30, 2016; R. Kühne, personal communication, April 8, 2016). We implemented similar software in the iPad application.

The primary reason museums track visitors is to improve exhibits. Staff described exhibit design as an iterative process. For some, this meant lots of prototyping before they selected a final design (L. Courtney, personal communication, March 30, 2016), but for others like the Philadelphia Museum of Art, exhibits continue to evolve and are never finished (J. Helmer, personal communication, April 4, 2016). Changes between iterations at various museums took the form of everything from small word changes to the removal of entire technologies (B. Loring, personal communication, March 25, 2016, L. Courtney, personal communication, March 30, 2016; J. Sacco, personal communication, March 28, 2016). For some museums such as the EcoTarium, this meant well over 50 iterations for most interactive exhibits (B. Loring, personal communication, March 25, 2016)

Finally, staff warned against designing exhibits with untested technology. Even the MFA, a museum renowned for modernity, informed us that they “don't try to be on the bleeding edge” (B. Martin, personal communication, March 30, 2016). For new technology, cost and reliability are the largest problems (V. Bumpus, personal communication, March 25, 2016; J. Sacco,

personal communication, March 28, 2016). The best example we encountered was the use of proximity beacons, which signal smartphones and display content. Both the MFA and Harvard Museums of Science and Culture prototyped these devices, but found them “buggy” (B. Martin, personal communication, March 30, 2016; J. Sacco, personal communication, March 28, 2016). For several other area museums, they were a “waste of money” (personal communications, March, 2016) Beacons are now greatly improved over previous generations and recently used at the Philadelphia Museum of Art (J. Helmer, personal communication, March 15, 2016), illustrating the reason many museums prefer to use well tested technology.

FINDING 9: THE LAYOUT OF THE MUSEUM AND EXHIBIT PLAYS A KEY ROLE IN AUDIENCE ENGAGEMENT.

The physical layout and design of the museum must appeal to visitors and make them feel comfortable on a variety of levels. This was commonly reported both in the literature and in our interviews. The museum must be welcoming to its visitors in demeanor, and the height of installations must be accessible to adults and children alike. Open spaces capable of holding the intended audience and floor plan are also important to consider for accessibility.

Welcoming Atmosphere in the Museum

The museum building, especially the lobby, make a first impression on the visitor and therefore must make the visitor feel welcome. According to researcher Stephen Bitgood, museum architecture should prevent distracting sounds and movement (personal communication, March 18, 2016). Additionally, adequate lighting is required for visitors to see the exhibit details, according to the USS Constitution Museum’s Robert Kiihne, Director of Exhibits (personal communication, April 8, 2016). In surveys at the WAM, 9 visitors out of 453 noted the glare caused by lighting, particularly in the American Galleries, and how it obscured details in the

artwork; given that it was a general survey on the visitor's experience at the WAM, all of these visitors included this sentiment in the additional comments section (Worcester Art Museum, 2016).

Height Tailored to Audience

The height of installations was also particularly important in accessibility for family audiences. The Philadelphia Museum of Art installed the objects for the Art Splash summer program so they could be viewed from a child's height, according to Elizabeth Baill, Manager of Family Gallery Learning (personal communication, April 6, 2016). Janis Sacco, Director of Exhibitions at the Harvard Museums of Science and Culture, emphasized the importance of displaying objects at eye level (personal communication, March 28, 2016). The Eric Carle Museum of Picture Book Art hangs paintings at a 54 inch centerline, two inches lower than most museums, to provide a better viewpoint for their young audience (E. Keiter, personal communication, April 8, 2016). The Museum of Russian Icons similarly provided low displays for better accessibility (L. Garrity-Arquitt, personal communication, April 6, 2016) and the EcoTarium used stools for the same purpose (B. Loring, personal communication, March 23). Betsy Loring from the EcoTarium and Julia Dolan from the Portland Art Museum both mentioned the ADA (Americans with Disabilities Act) regulations for accessibility, including height requirements of interactives and installations (B. Loring, personal communication, March 23, 2016; J. Dolan, personal communication, March 23, 2016; personal communication, March 25, 2016).

Open Spaces for Accessibility

Another key aspect of museum layout included open space for accessibility and holding larger audiences. Elizabeth Baill advocated leaving enough room in exhibitions for educators to

bring large groups who could then look, play, and explore (personal communication, April 6, 2016). According to Stephen Bitgood and Minda Borun, displays should have multiple sides to allow groups and families to gather around at the same time (2013; 2013). Based on our interviews at the EcoTarium, the Museum of Russian Icons, and the Museum of Fine Arts, exhibits should be nonlinear in order to provide freedom of movement (B. Loring, personal communication, March 23, 2016; L. Garrity-Arquitt, personal communication, April 6, 2016). According to Saul Carliner, Professor of Education and Program Director at Concordia University, exhibit design should be tailored to the message meant to be conveyed—for example, a linear exhibit could fit a historical sequence of events—and should also take into consideration floor space, accessibility, visitor movement, and key items (2001).

The Floor Plan and the Visitor's Needs

The final important considerations, particularly for museums appealing to families, are rest areas and the proximity of museum features and amenities. At the Museum of Russian Icons, the EcoTarium, the Boston Museum of Science, the WAM, and the Philadelphia Museum of Art there were spaces designated for children to play, in the case of the WAM, Helmutt's House in the Knights! exhibit in Figure 4.7 (L. Garrity-Arquitt, personal communication, April 6, 2016; B. Loring, personal communication, March 23, 2016; observation, March 30, 2016; observation, February 17, 2016; E. Baill, personal communication, April 6, 2016).



Figure 4. 7: Helmutt's House Rest Area in the Knights! exhibit

Another key consideration at the Philadelphia Museum of Art was the close proximity of exhibits to each other, to the cafe, and to bathrooms (E. Baill, personal communication, April 6, 2016). Providing seats in exhibits or at an interactive increased visitor linger time, and a study at the Denver Museum of Art found 40% of visitors preferred to view exhibits seated (Bitgood, 2013). The WAM invites visitors to either rest or spend an extended time viewing paintings using chairs in the galleries (observation, April 8-10, 2016). At the Museum of Fine Arts in Boston, many of the interactives, such as designing a coin in the coin exhibit or selecting the final piece to an exhibit from three pieces, provided large screens and a few chairs so that a group of visitors would be able spend more time on the activity (observation, March 23, 2016). The Peabody Essex Museum stressed the importance of seating wherever books were provided (E. Rodley, personal communication, April 11, 2016).

4.4 VISITOR'S RECEPTION TO THE WAM'S MEDIA.

FINDING 10: THE MUSIC IN THE KNIGHTS! EXHIBIT DID NOT ELICIT STRONG FEELINGS IN SURVEY RESPONSES, BUT IT DID PROMOTE CONVERSATION AMONG VISITORS.

According to survey responses collected prior to our project in the Knights! exhibit, out of 319 responses, 10 visitors mentioned sound in the additional comments section (Worcester Art Museum, 2016). Of these 10 responses, one was positive, the remaining 9 found the music distracting, annoying, jarring, or out of place, and one visitor recommended using medieval music instead (Worcester Art Museum, 2016).

Observation conducted in the Knights! exhibit indicated that the audio cones, the sound devices playing music from the ceiling in a focused spot, clashed with the collection by playing songs similar to "We are the Champions", but they created a more social atmosphere (observation, April 8-10, 2016). The sound in the gallery seemed to provide an incentive for discussion, as most of the visitors engaged in conversation using at normal volume. In stark contrast, we observed in the more traditional Remastered gallery only occasional whispering but usually silence (observation, April 8-10, 2016).

FINDING 11: THE IPADS AT THE WAM WERE LARGELY UNUSED, BUT FAIRLY WELL RECEIVED BY THOSE WHO DID.

Surveys of visitors in the Knights! exhibit showed that visitors liked the tablets and the labels, finding them generally helpful. However many felt that they were too sparse or did not provide enough information. Additionally, visitors appreciated the educators on hand in the exhibit. A few commenters took the opportunity to ask questions about the exhibit, such as the pink horse out front (Worcester Art Museum, 2016). See the distribution of responses in Figure 4.8.

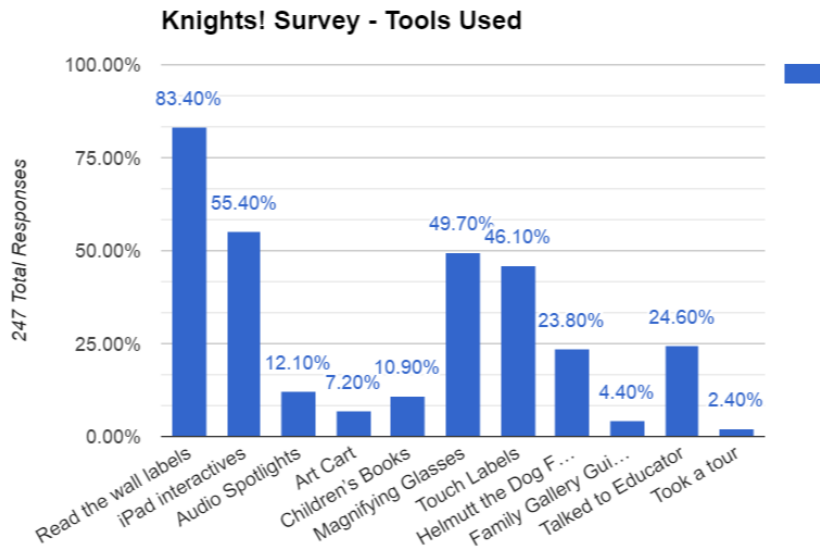


Figure 4. 8: Percentage of visitors that used given tools at Knights! exhibit (data from Worcester Art Museum, 2016)

When asked how the exhibit could be made more appealing, visitors frequently requested an increase in interaction, especially as some kind of hands-on opportunity with the items (see Figure 4.9 for greater detail). Others suggested included expanding the iPad implementations or having an educator around to teach about the items' history (Worcester Art Museum, 2016).

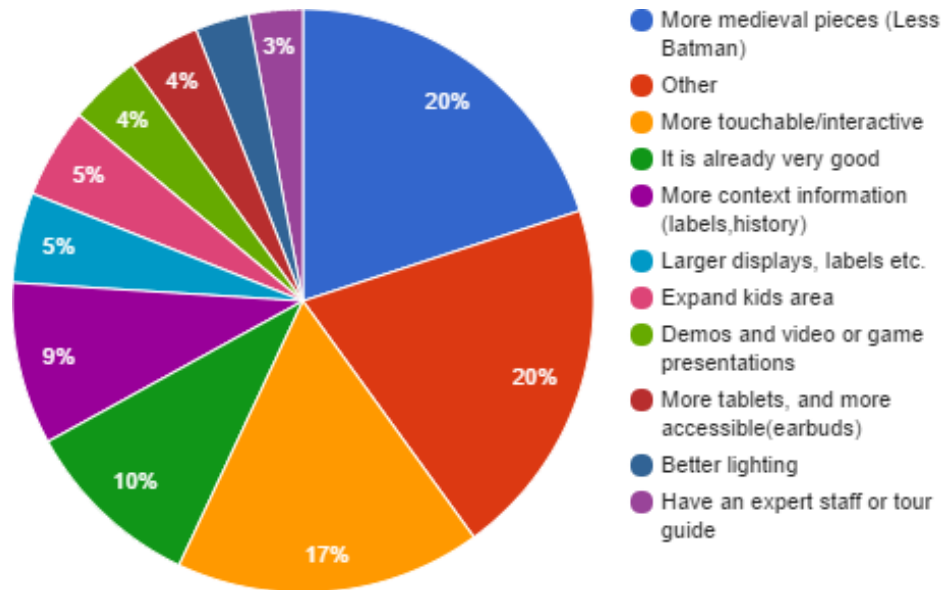


Figure 4.9: Percentage of visitors that gave specific feedback on Knights! Exhibit (data from Worcester Art Museum, 2016)

Despite this information, we learned that what visitors say they do is not always in line with what they actually do. In Figure 4.9 above, 55% of visitors said they used the iPads in the Knights! exhibit. We performed human observation to track visitor use of iPads over a typical weekend at the WAM. From April 8, 2016 to April 10, 2016 we observed visitor interactions with the iPads in the Remastered Gallery and the Knights! exhibit. Curator Jeffrey Forgeng and other staff advised that the best hours to observe visitors was from 12pm to 2pm (personal communication, April 2016). Out of the 130 visitors we observed in the Remastered Gallery, only 13 (10%) actually used the iPads (observation, April 8-10, 2016). Those that did use the iPads spent an average of 1 minute 20 seconds looking through the media (observation, April 8-10, 2016). In the Knights! exhibit, only 11 out of the 141 visitors (8%) we observed interacted with the iPads (observation, April 8-10, 2016). iPad users in the Knights! exhibit spent an average of only 20 seconds looking through the material (observation, April 8-10, 2016).

An interview with WAM gallery attendant Robert Cardoza, who has worked at the WAM for ten years, supported our observations. He asserted that very few visitors interact with the iPads and those that did were usually directed to use them by members of the staff (personal communication, April 19, 2016). We also interviewed WAM gallery attendant Barin Bando, who has worked at the WAM for over a year, and he observed that very few people went out of their way to use them and often did not spend an extended period of time perusing the contents (personal communication, April 20, 2016). In spite of this, the iPads were very well received overall by those that did use them and were rated highly by visitors who filled out surveys (Worcester Art Museum, 2016). The results of an online Survey Monkey questionnaire distributed by the WAM can be seen in Figure 4.10.



Figure 4. 10: WAM iPad Survey Responses (Worcester Art Museum, 2016)

This survey included 710 responses from November 2014 to February 2016 at the WAM. The majority of respondents rated the iPads as excellent (Worcester Art Museum, 2016). Only 5% of respondents rated the iPads as poor, so we deduced that visitors generally enjoyed using the iPads and their features (Worcester Art Museum, 2016).

5. DELIVERABLES

We provided three deliverables to our sponsor, Jeffrey Forgeng, based on our research into the effectiveness of using technology to engage a family audience in a museum. First, we programmed an iPad application for the Meyer Idea Lab Exhibit. Second, we created a promotional video featuring the arms and armor exhibits and Swordplay Workshops from a unique perspective. Third, we generated a list of recommendations for future technology use in the Worcester Art Museum.

5.1 IPAD APPLICATION FOR THE MEYER IDEA LAB EXHIBIT

The Meyer Idea Lab, opening May 28, 2016, will feature the *Art of Combat* manuscript produced by Joachim Meyer. The exhibit will present additional information to visitors on three iPads containing six different functionalities at the request of our sponsor (J. Forgeng, personal communication, February 10, 2016). We designed the application using Unity, a cross-platform game engine.

While we explored different options for implementing the application (see Appendix I for more details), we selected Unity because one of the features our sponsor wished to include was already developed using Unity, so it would be simple to combine the new features with the game. Additionally Tim Furman, Web Design Coordinator and Graphic Designer, expressed his dissatisfaction with the WAM's current platform, Kiosk Pro, and was very interested in trying Unity (personal communication, April 1, 2016). We also discovered from our interviews that the EcoTarium already used Unity, and their Director of Exhibits, Betsy Loring, recommended the platform (personal communication, March 23, 2016).

When creating the theme for the iPad app, we applied some of our discoveries from Finding 6. Based on the advice we received at the Museum of Fine Arts of matching the media

style to the collection, we gave the application a general medieval theme to blend with the exhibit (L. Courtney, personal communication, March 30). We also did not want the touch screen to be distracting to the visitor, based on Betsy Loring's caution about children tending to misuse screens, so we made the interface simple and with clear instructions (personal communication, March 23, 2016).

From our observations in the Museum of Fine Arts and the Knights! Exhibit (Finding 7), visitors did not activate the touch screens without being directed by either an instruction to touch the screen, as provided at the MFA, or by a gallery attendant, as we observed at the WAM (observation, March 30, 2016; observation, April 8-10). To encourage the visitor to interact with the screen, we included "Touch to Begin" on the screensaver (see Figure 5.1).



Figure 5. 1: iPad Screensaver Urging Visitors to Interact with It

Once a visitor follows the displayed instructions and touches the start screen, the application transitions to the main menu (See Figure 5.2). From here, the visitor can reach any of the six features included in the gallery application. The main menu also allows the visitor to view the application credits.

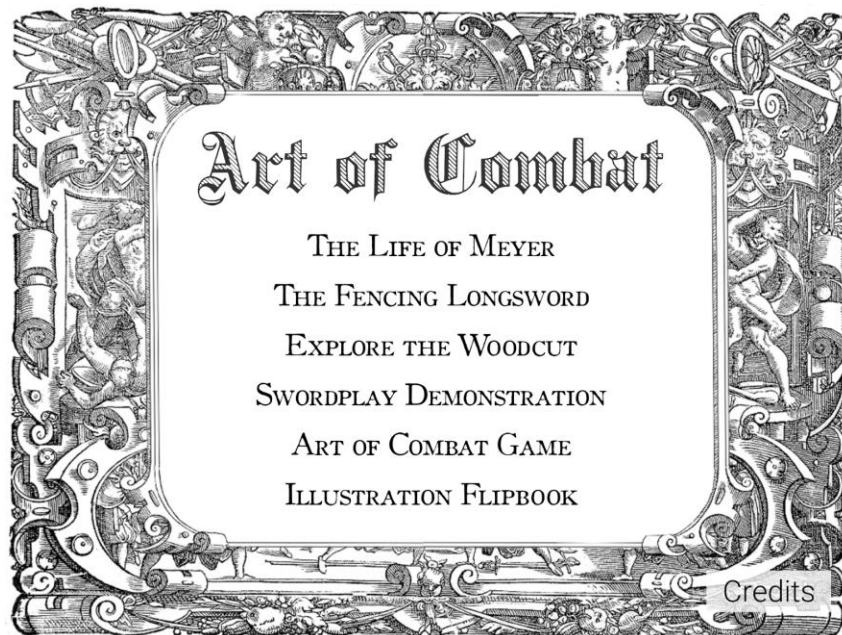


Figure 5. 2: iPad Main Menu

Selecting one of the first two options, *The Life of Meyer* or *The Fencing Longsword*, will load a slideshow presentation (See Figure 5.3). Each slide has content text and an accompanying image.



EARLY LIFE

Joachim Meyer was born in Basel, Switzerland, and moved to Strassburg to work as a blademaker. Strassburg is now in France (and called Strasbourg) but in Meyer's day it was considered a part of Germany. In Meyer's spare time he taught swordplay and other martial arts, and organized public fencing matches.



Figure 5. 3: Slideshow Presentation of Historical Context

As an extra feature, tapping the slide image will reveal the full-size original image (see Figure 5.4). This feature allows the user to experience the satisfaction of discovering something hidden, thus giving them a sense of ownership and accomplishment. This sense of ownership, as discussed in Finding 5, can help the visitor form a connection and own his or her visit.



Close

Figure 5. 4: iPad Zoom-in Feature

The third option, *Explore the Woodcut*, helps draw the visitor's attention to details in one of the woodcuts from Meyer's book. When the visitor taps on one of the highlighted sections, the woodcut zooms in on the selected section and provides interesting contextual information (See Figure 5.5). This process of drawing the visitor's attention to the details we observed in the Museum of Fine Arts, the Museum of Russian Icons, and the WAM (observation, March 30, 2016; observation, March 6, 2016; observation, April 8-10, 2016).

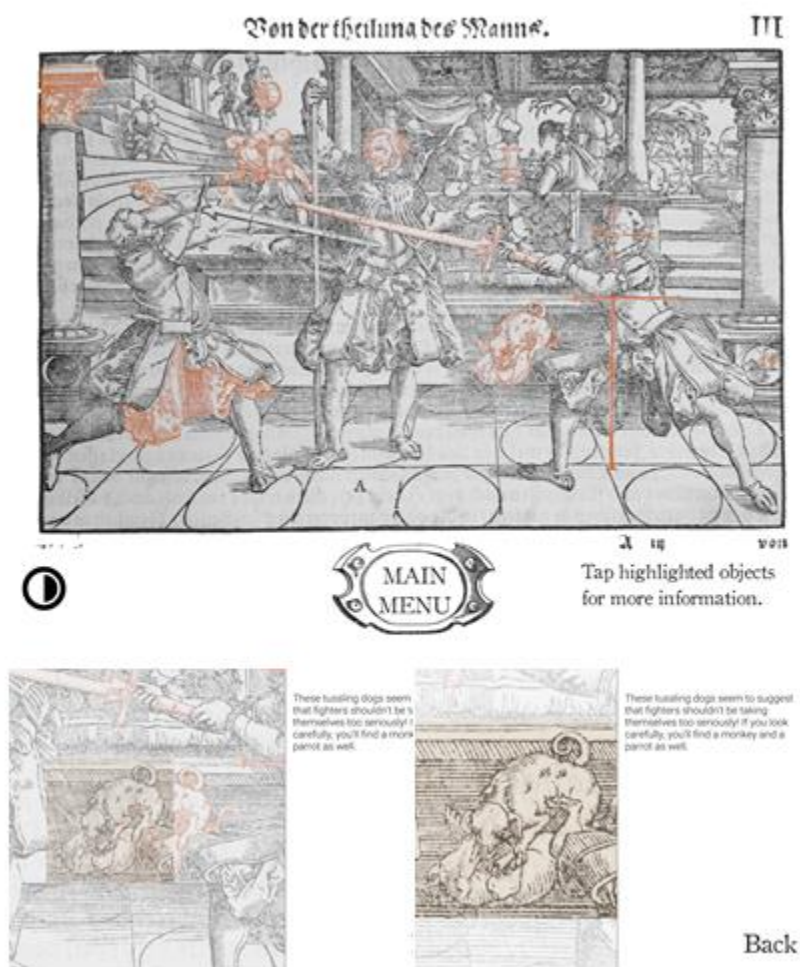


Figure 5. 5: Explore the Woodcut with Zoom-in iPad Feature

Based on our research on accessibility in museums as well as our interview with Lynn Courtney at the Museum of Fine Arts, we made the text large and provided a high-contrast,

interactive woodcut illustration for those who are vision-impaired (Silverman, 2010; Simon, 2010; personal communication, March 30, 2016). See this feature in Figure 5.6, as a few people willing to test the application commented that some of the highlights were not clearly visible to them.

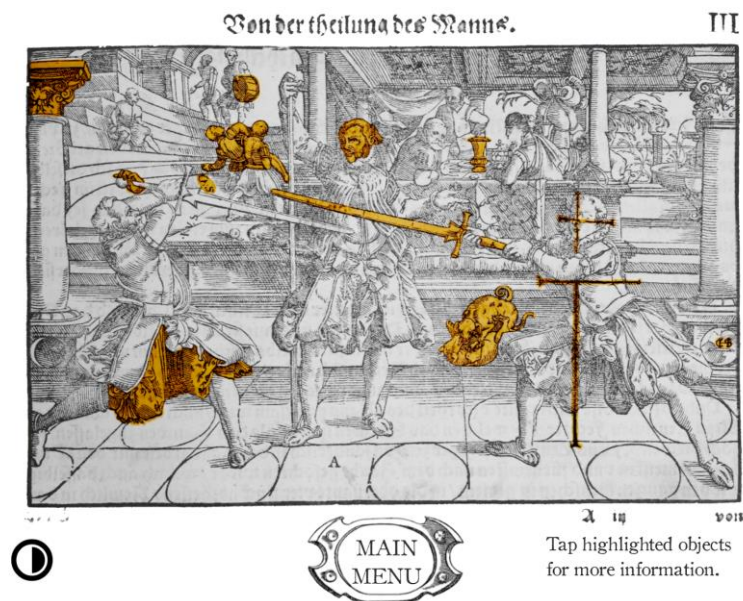


Figure 5. 6: High-Contrast Explore the Woodcut iPad Feature

The fourth option, *Swordplay Demonstration*, shows two fencers engaging in a brief bout of swordplay (See Figure 5.7). By selecting Breakdown, the visitor can watch a video clip that breaks down the bout and explains the individual maneuvers made by the fencers. Jeffrey Forgeng's decision to include this feature was supported by our fifth finding, that a video is a good method of providing demonstrations or showing things that are hard to display through text alone (L. Courtney, personal communication, March 30, 2016).



Figure 5. 7: Swordplay Demonstration iPad Feature

The fifth option allows the visitors to play a game created by Charlie Bickle, Christopher Ellen, Joshua O'Connor, and Mi Tian, a previous team of WPI students working under the direction of Jeffrey Forgeng (2014). The game demonstrates some of the basic techniques described in Meyer's *Art of Combat*. Each turn, the player can select one of three moves to attack the opponent swordsman. The computer will select one of three attacks for the opponent swordsman. Depending on the moves selected by the player and the game, the round will result in a win, a loss, or a draw. A sample round can be seen in Figure 5.8. The first swordsman to win five rounds wins the game.

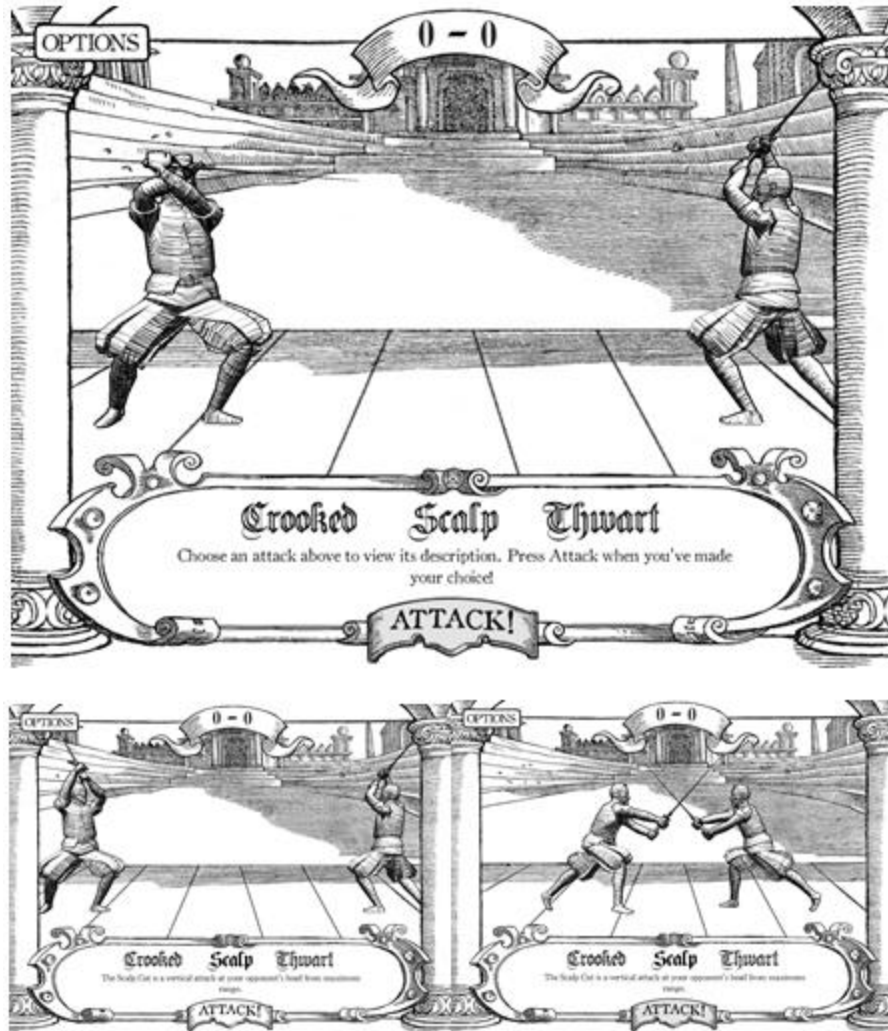


Figure 5.8: Playing the Art of Combat Game

The sixth and final option, *Illustration Flipbook*, allows the visitor to flip through the various intricate Woodcut illustrations in Meyer's *Art of Combat* (See Figure 5.9).



Figure 5.9: Illustration Flipbook of the Woodcuts from Meyer's *Art of Combat*

Thus, we created the application containing these six features impacted by our findings for the upcoming Meyer Idea Lab. In order to allow the WAM to improve their exhibits, based on Finding 8 where we discussed how exhibit design is an iterative process, we provided a software tracking feature. This feature was mentioned during our interview at the Museum of Fine Arts, and it matched very well with monitoring how the visitors use the media available to them (L. Courtney, personal communication, March 30, 2016). To implement the iPad application features and to access the software tracking log, refer to Appendix J.

5.2 PROMOTIONAL VIDEO

We created a five minute promotional video to be posted on the WAM's social media outlets with the goal of increasing engagement with the recent focus on arms and armor. The video includes brief mentions of current and upcoming arms and armor exhibits as well as the Swordplay Workshops hosted by the WAM. The rest of the video includes historical trivia pertaining to Joachim Meyer and *The Art of Combat* to build interest. As recommended by our

findings, manually-produced closed captions are also available to make the video more accessible to viewers who may be hard of hearing. The video's script was more lighthearted than the WAM's in-house productions to hopefully help attract a wider audience and garner attention with its unorthodox presentation.

The video can be accessed at <https://www.youtube.com/watch?v=EoN2OJuv-IY>

5.3 FINAL RECOMMENDATIONS FOR THE MEDIEVAL GALLERY AND FUTURE EXHIBITS AT THE WAM

In the previous chapter, we described our project findings and the breadth of material we learned on technology use in museums. In this section, we present our final recommendations for the Medieval Gallery and future exhibits at the WAM. Additionally, we provided a reference in Appendix H, summarizing the strengths and weaknesses of specific technologies, as informed by our findings.

We learned that every technology can have its place in a museum, but that not all approaches are appropriate for a family-oriented exhibit in a mid-sized New England art museum, such as the WAM. Below is a condensed summary of our final recommendations, followed by further description of each point. For more detailed reasoning, see the Findings sections referenced in the recommendations and the tables in Appendix H.

Final Recommendations

1. **Only use digital technology when the same content cannot be effectively provided in another way.**
2. **Distribute printed guides to visitors.**
3. **Provide magnifying glasses around exhibits.**
4. **Use push-button audio stations to compliment labels and provide additional stories.**
5. **Use video to show demonstrations.**
6. **Experiment with ambient music.**
7. **Provide a rest area with seating, books, and arts and crafts.**
8. **Make displays multi-sided within an open area.**
9. **Allow for free-choice travel through exhibits.**
10. **Test and make many iterations with visitor observation.**

RECOMMENDATION 1: ONLY USE DIGITAL TECHNOLOGY WHEN THE SAME CONTENT CANNOT BE EFFECTIVELY PROVIDED IN ANOTHER WAY.

We found that tablets, handheld multimedia devices, and other digital media are ineffective when not implemented well. The WAM's arms and armor collection targets the family audience. Children are particularly susceptible to being distracted by digital technology, and many parents bring their children to museums to get them away from screens (Finding 6). Group interaction is also important for families in a museum (Finding 5), but many of these technologies only allow for one user at a time so the individual is isolated from the group. Finally, some visitors ignore or avoid digital technology (Finding 7), such as when we observed only 9% of visitors used the iPads in the Knights! exhibit (Finding 11). There are times when

digital displays are the only way to provide an experience, but otherwise we recommend simpler and more conventional means, which are used by more visitors (Finding 8).

RECOMMENDATION 2: DISTRIBUTE PRINTED GUIDES TO VISITORS.

Over a century of studies have pointed out the benefits of guides in museums (Finding 5). Printed guides are a low cost alternative to portable media devices with similar capability for navigation and guiding visitor focus (Finding 5). Additionally, visitors can take the guides home as mementos afterwards (Finding 5). However, guides must be handed directly to visitors, or they will mostly be ignored (Finding 7).

RECOMMENDATION 3: PROVIDE MAGNIFYING GLASSES AROUND EXHIBITS.

Technology provides the benefits of a creating multisensory experience, as well as helping visitors better appreciate detail (Finding 5). Magnifying glasses do this by providing both a tactile and visual experience, while encouraging visitors to take a closer look. Unlike tablets which perform the same function, magnifying glasses do not require the visitor to draw their gaze away from the objects on display (Finding 6). If objects must be protected behind glass, they should be arranged so that magnifying glasses can still be used whenever possible.

RECOMMENDATION 4: USE PUSH-BUTTON AUDIO STATIONS TO COMPLIMENT LABELS AND PROVIDE ADDITIONAL STORIES.

The combination of labels and audio stations provides a multisensory experience for visitors, while creating opportunity for language selection and aid for those with sensory impairments (Finding 5). Additionally, labels and audio-stations can be used by a group or family (Finding 5). Labels should be used to provide important information, tell stories, and guide visitor attention to details. Button-activated audio stations should be used for a similar purpose, especially when voice acting and theatrical reading can benefit storytelling. Content

should be at about a middle school reading level, allowing adults to help children interpret when necessary (Finding 5). We encourage the use of storytelling to prevent visitors from getting bored and ignoring the content (Finding 7).

RECOMMENDATION 5: USE VIDEO TO SHOW DEMONSTRATIONS.

We recommend the use of some televisions because they are capable of delivering a multimedia experience to a group of visitors (Finding 5). However, televisions completely draw the visitor's attention away from the objects on display (Finding 6), and should therefore only be used to show demonstrations which would otherwise be difficult to describe in words or to provide a break from viewing objects (Finding 5).

RECOMMENDATION 6: EXPERIMENT WITH AMBIENT MUSIC.

Ambient music can function as both an icebreaker for visitors and aid in drowning out background noise. Music encourages visitors to feel comfortable talking in an exhibit (Finding 10), and interaction is particularly important with families (Finding 5). Additionally, noise from audio devices can be annoying or distracting, and ambient music helps to cover this up (Finding 6).

RECOMMENDATION 7: PROVIDE A REST AREA WITH SEATING, BOOKS, AND ARTS AND CRAFTS.

Seated rest areas can serve a variety of purposes in the WAM. Seating can give visitors a place to rest, work on crafts, and read books. These rest areas allow families to take a break from viewing exhibits (Finding 3; Finding 9), and provide a place to sit for those who prefer to view exhibits while seated (Finding 9). Additionally, book and arts and crafts contribute to a multisensory experience, but hold visitors for a long time, up to 20 minutes, so seating is essential (Finding 5). Hands-on items such as the castle building blocks or interactive pieces of

armor from the Higgins Armory can go here. Finally, crafts give visitors something to take home (Finding 5).

RECOMMENDATION 8: MAKE DISPLAYS MULTI-SIDED WITHIN AN OPEN AREA.

Multi-sided exhibits allow groups of visitors to interact with an object, which is important for a family audience (Finding 5). This also provides more space for the use of magnifying glasses (Recommendation 3), and additional means of interaction (Finding 5)

RECOMMENDATION 9: ALLOW FOR FREE-CHOICE TRAVEL THROUGH EXHIBITS.

Visitors should feel free to navigate to any area they wish without being confined to a particular path. Providing open space increases accessibility and provides freedom of movement (Finding 9). Additionally, visitors can move to and focus on content and experience which they find particularly interesting (Finding 5).

RECOMMENDATION 10: TEST AND MAKE MANY ITERATIONS WITH VISITOR OBSERVATION.

Most museums go through extensive testing with new exhibits, looking at how visitors interact (Finding 8). While visitor observations are generally considered more reliable than surveys (Finding 8), surveys still provide useful qualitative data on visitor enjoyment (Finding 11).

6. CONCLUSION

The Worcester Art Museum has already made great strides towards better engaging family audiences. Exhibits such as Knights! have already implemented many of the recommendations that we formed from our findings. We believe that the iPad application will help to address the low usage rates of tablets in the past, and that the visitor tracking software

will improve the iteration process for WAM tablet application design. We also believe that the video will help draw attention to the Meyer Exhibit and swordplay workshops. Finally, by implementing the recommendations, we are confident that the WAM can better provide families with a personalized and self-guided museum visit that incorporates sight, sound, and touch for a more immersive and engaging experience.

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APPENDIX A: INTERVIEW QUESTIONS, JEFFREY FORGENG

1. What are your expectations for the scope of the project?
2. Do you seek a design idea, or perhaps do you already have an approach in mind and would prefer that we work to implement it?
3. What is the overarching goal of the project?
4. What is the purpose of the Knights! exhibit?
5. Do you want to implement new technology to enhance the experience of your current visitors, or are you primarily seeking to capture a larger audience?
6. Do you have a target audience in mind for whom you are conducting the change?
7. What do you foresee as the budget of this endeavor?
8. How do you intend to publicize this once it goes into effect?
9. Would the entire museum be seeking digital technology to enrich the experience, or perhaps would consider it eventually?
10. Have you considered incorporating the weapons and armor with the artifacts from corresponding time period and location? What is your opinion of this?
11. What is your opinion of the audio tours available? Have you listened to them?
12. How do you currently survey your visitor base? Would you be willing to share the responses with us?
13. Is there anything that you think it would be beneficial for us to know?
14. Is there anyone else we should talk to?
15. How should we contact you in the future?

APPENDIX B: INTERVIEW QUESTIONS, WORCESTER ART MUSEUM EDUCATORS

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with curators and other museum staff to learn more about museum exhibit design and engagement techniques. We strongly believe this kind of research will ultimately enhance the visitor experience and the long-term success of the Worcester Art Museum (WAM). Your participation in this interview is completely voluntary, and if you wish, your answers will remain confidential, such that no names or identifying information will appear in any of the project reports or publications.

Interview Questions:

1. How long have you been with the Worcester Art Museum?
2. What is your role at the Worcester Art Museum? In the Meyer Idea Lab project?
3. What is your vision for the Meyer Idea Lab?
4. What is your opinion of the use of technology in museum exhibits?
5. What is the role of the art museum?
6. Could you recommend anyone else we might speak to about engaging exhibit design approaches, both at the WAM and elsewhere?
7. If we have additional questions, is it alright if we contact you? How would you prefer to be contacted?
8. Do we have your permission to associate your name with your responses?
9. Thank you for your time.

APPENDIX C: INTERVIEW QUESTIONS, MUSEUM STAFF

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with curators and other museum staff to learn more about museum exhibit design and engagement techniques. We strongly believe this kind of research will ultimately enhance the visitor experience and the long-term success of the Worcester Art Museum (WAM). Your participation in this interview is completely voluntary, and if you wish, your answers will remain confidential, such that no names or identifying information will appear in any of the project reports or publications.

Interview Questions:

1. How long have you been with the museum?
2. What is your role at the museum?
3. What is your museum's target audience?
4. How does your target audience shape your exhibit design approach?
5. Does the museum have a specific approach to engaging visitors? If so, can you tell us a bit about that approach?
6. Can you describe any specific benefits and/or drawbacks of this approach?
 - a. Have you noticed a change in attendance?
 - b. Do some implementations seem to be more effective than others?
 - c. Have you conducted any studies on visitor engagement in your museum? Would you be willing to share your findings?
7. (Only asked at art museums) What is the role of an art museum?
8. What is your opinion of the use of technology in museum exhibits?
9. Are there any technologies that you wish to implement in the museum which you do not presently have implemented?
10. Could you recommend anyone else we might speak to about engaging exhibit design approaches, particularly digital implementations?
11. If we have additional questions, may we contact you? How should we contact you?
12. Do we have your permission to associate your name with your responses?
13. Thank you for your time.

APPENDIX D: INTERVIEW QUESTIONS, GALLERY ATTENDANTS

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting interviews with curators, guards and other museum staff to learn more about museum exhibit design and engagement techniques. We strongly believe this kind of research will ultimately enhance the visitor experience and the long-term success of the Worcester Art Museum (WAM). Your participation in this interview is completely voluntary, and if you wish, your answers will remain confidential, such that no names or identifying information will appear in any of the project reports or publications.

In order to provide some context, we have been conducting visitor observation studies in the Knights and Remastered exhibits, and we decided, with the advice of Adam Rozan, to speak to those who actually interact with and observe the visitors frequently. We are especially grateful for your insight, because you get to observe hundreds of visitors, and how they use or experience the museum. We hope that our observations and yours can be used to improve audience engagement at the WAM.

Interview Questions for Guards at the WAM:

1. How long have you been working at the Worcester Art Museum?
2. Tell me a little about the role of a guard at the Worcester Art Museum.
3. Which galleries do you primarily spend your time in?
4. In the galleries you work in (consider them one at a time), consider the following.
 - a. What have you observed about:
 - b. How visitors interact with the collection (Specifically where they linger, which items catch their attention, how they traverse)?
 - c. How visitors interact with each other? (discussion, travel, linger)
 - d. How the visitors use iPads? Laminate guides? Labels? (Are there particular visitors that use them, are there particular visitors you expect will use them?)
 - e. How visitors interact with you and other guards?
 - f. Other aspect(s) that stand out to you?
5. Based on your observations, what is your opinion of the use of technology in museum exhibits? Specifically the iPads? Of audio guides?
6. This question is much more general: what do you think is the role of an art museum? How do you fit into that role?
7. If we have additional questions, is it alright if we contact you? How would you prefer to be contacted?
8. Do we have your permission to associate your name with your responses?
9. Thank you for your time.

APPENDIX E: ENGAGING EXHIBIT DESIGN RUBRIC

Museum:

Exhibit:

Technology:

	Scaling Factor	4 Excellent	3 Good	2 Mediocre	1 Poor
Appeals to diverse learning styles					
Appeals to all Ages (Family Oriented)					
Visitor Reception (observation/surveys)					
Popularity (visitor rates)					
Maintenance Required					
Implementation Expenses					
Sanitation					
Safety					
Relevance to Exhibit					

Notes:

APPENDIX F: HUMAN OBSERVATION, WORCESTER ART MUSEUM

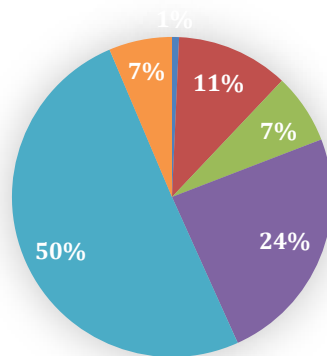
Knights! exhibit observation: April 8-10, 2016



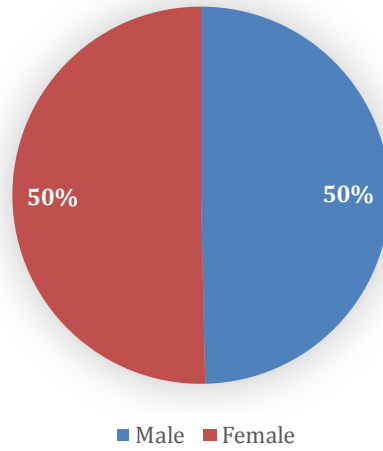
A group of students from Worcester Polytechnic Institute are conducting a study where they are observing visitor linger time in the Knights Exhibit at the Worcester Art Museum.

Age of Visitors

■ Baby ■ Child ■ Teen ■ Young adult ■ Middle aged ■ Senior

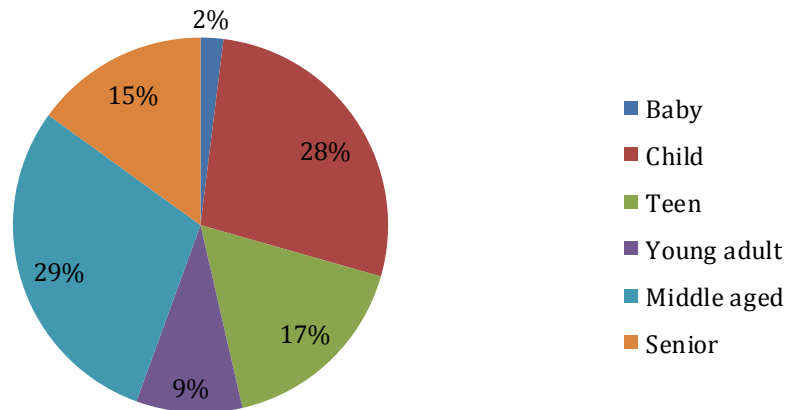


Gender of Visitors

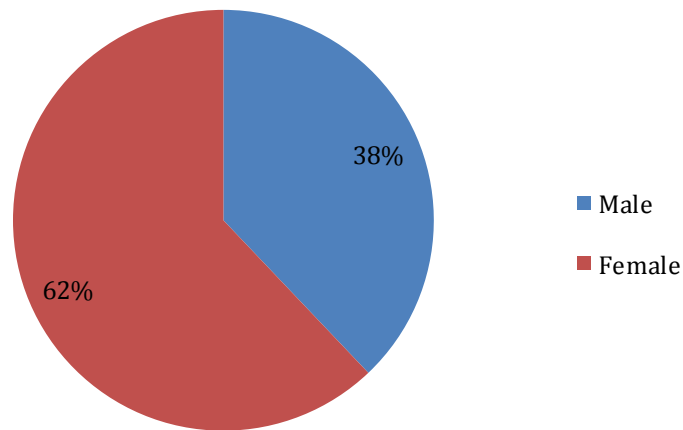


Knights! exhibit observation: April 20-22, 2016

Age of Visitors



Gender of Visitors



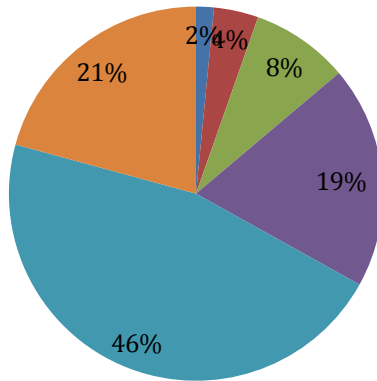
Remastered observation: April 8-10, 2016



A group of students from Worcester Polytechnic Institute are conducting a study where they are observing visitor linger time in the Remastered Gallery at the Worcester Art Museum.

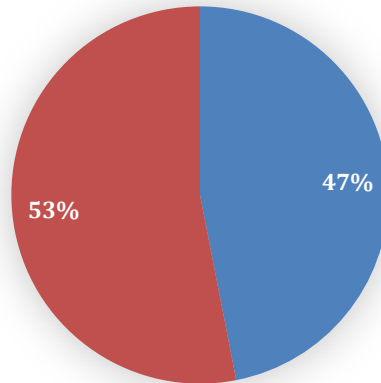
Age

Age of Visitors



■ Baby ■ Child ■ Teen ■ Young Adult ■ Middle ■ Senior

Gender of Visitors



■ Male ■ Female

APPENDIX G: ORAL iPad SURVEYS, KNIGHTS! (WORCESTER ART MUSEUM)



A group of students from Worcester Polytechnic Institute are conducting a study and would like your feedback on the Knights Exhibit at the Worcester Art Museum.

1. On a scale of 1-10, (worst-best), what is your overall impression of the iPad?
2. What is your favorite feature of the iPad?
3. Is there anything that we could have done better or improve on?
4. Have you used another iPad in the museum? If yes, what was your opinion on that one?
5. Is there anything else about the museum in general that you enjoyed?

APPENDIX H: OVERVIEW OF TECHNOLOGIES

General recommendations

- + Only use technology if it serves a clear purpose in the exhibit
- + Avoid untested technologies; they're expensive.
- + Provide a variety of methods for interacting. This both keeps the exhibits fresh and appeals to visitors who prefer different learning styles.
- + Give visitors something to hold.
- + Keep content concise and interesting, focusing on stories over facts (expert accounts can be used as stories).
- + Consider providing information in multiple languages.
- + Provide visitors with some way of owning their visit (photographs, drawings, building blocks, etc.).

NON-DIGITAL TECHNOLOGIES

Labels

Pros	Cons
<ul style="list-style-type: none"> + Most commonly used way to communicate information with visitors + Minimal distraction + Small and relatively compact + Multiple languages can be provided 	<ul style="list-style-type: none"> - Limited depth of information - Can be difficult for visually impaired
Recommendations	
<p>We recommend using labels in all exhibits unless a very good reason exists to not. Labels are still ubiquitous in museums and the majority of visitors read them. Labels can only provide a small depth of information without becoming too lengthy for visitors to read, but this is plenty space to provide interesting insight and tell stories.</p>	

Guides

Pros	Cons
<ul style="list-style-type: none">+ Greatly enhance time in exhibits+ Guide visitors around exhibits+ Point out details of items+ Provide interesting facts or activities+ Inexpensive+ Can serve as a take-home+ Minimally distracting+ Simple and easy to use+ Something for visitors to hold	<ul style="list-style-type: none">- Limited amount of information- Low usage rates unless given out
Recommendations	
<p>We recommend handing out guides to visitors. Over a century of studies have pointed out the benefits of guides in museums. Printed guides are a low cost alternative to portable media devices with similar capability for navigation and guiding visitor focus. Although less information can be included, this is likely still well within what visitors are willing to read. Additionally, visitors can take the guides home as mementos afterwards. Guides must be handed out to visitors or they will not use them.</p>	

Magnifying glasses

Pros	Cons
<ul style="list-style-type: none">+ Allow visitors to inspect details+ Self-guided exploration+ Interactive and hands on+ Relatively inexpensive+ 49.7% of visitor to Knights! reported using magnifying glasses	<ul style="list-style-type: none">- Risk damage to items- Minor risk of being stolen
Recommendations	
<p>We recommend placing magnifying glasses around the exhibit. These allow visitors to perform their own exploration of details while having something to hold. They are a non-digital, easy to use, interactive mechanic for exhibits and can replace the need for tablets to zoom into details.</p>	

Books

Pros	Cons
<ul style="list-style-type: none">+ Provide greater depth of information+ Allow personal-choice exploration+ Break from exhibit+ Occupy children+ Provide group interaction	<ul style="list-style-type: none">- Low usage rates- Seating must be provided
Recommendations	
<p>We recommend providing books as part of a rest area. Their low use does not warrant a separate area for reading, but visitors need a place to rest and there are no drawbacks to providing books. Books also provide families a way to entertain children in an interactive and audiovisual way.</p>	

Arts and crafts

Pros	Cons
<ul style="list-style-type: none">+ Provide physical interaction+ Ownership and take-home+ Appeal to both children and adults+ Break from the exhibit+ Inexpensive	<ul style="list-style-type: none">- Requires resupply and cleaning- Space requirements- Seating must be provided
Recommendations	
<p>We highly recommend providing crafts. Adults and children will both appreciate the chance to take a break as well as create something. Some visitors want to take creations home, while others want to leave creations as their own mark on the museum.</p>	

DIGITAL TECHNOLOGIES

Tablets

Pros	Cons
<ul style="list-style-type: none">+ Multimedia interaction+ Compact information+ Visitors choice of exploration+ Guide visitors to inspect details+ Satisfy the desire for touch+ Interactivity and feedback+ Allow creation and ownership+ Flexibility to change and repurpose+ Increasingly inexpensive+ Options for language and text size	<ul style="list-style-type: none">- Divert focus from objects- Only allow one user- Distracting to children- Visitors want to avoid screens- Maintenance and technical support- Uncomfortable for some to use- Only 10% used tablets in the WAM- Seating for longer experiences
Recommendations	
<p>We recommend a very limited use of tablets. Tablets are a compact and self contained way of providing the benefits of labels, audio tours, televisions, magnifying glasses, and toys in one device. They can be great for lone visitors or perhaps couples. However, due to their drawbacks, they should be avoided in family oriented museums unless their interactivity is absolutely required.</p>	

Televisions

Pros	Cons
<ul style="list-style-type: none">+ Simple and easy to use+ Audio-visual information+ Group viewing+ Language selection and closed captioning	<ul style="list-style-type: none">- Distracting audio and visual- Minimal interaction- Quickly lose interest- Screen burnout- Visitors arriving mid-video
Recommendations	
<p>We recommend the use of some televisions because they are capable of delivering a multimedia experience to a group of visitors, but they can also become distracting and annoying. If audio or potentially distracting video is presented, consider the use of push-button start (which can also be used for language selection) or physical isolation of video. Additionally hands-on technology such as Spinbrowsers can be used to increase interactivity.</p>	

Audio tours

Pros	Cons
<ul style="list-style-type: none">+ Audio experience+ Visual focus on object+ Guide visitors to inspect details+ Several forms of activation (beacons, numbers, image recognition, etc.)+ Tell stories and include voice acting+ Cheap and fast production+ Language selection+ Beneficial to sight-impaired+ Enough content for entire visit+ Something to hold	<ul style="list-style-type: none">- Headphone use can be anti-social- Require visitors to bring headphones- Non-headphone use creates noise- Little use by families with young children- Low usage rates unless given out
Recommendations	
<p>We recommend audio devices for providing another avenue for exploring the exhibit with few drawbacks. Audio tours provide a method of delivering engaging content directly to visitors without distractions. If activated by beacons, they are more convenient. If activated by number entry, they provide visitors with interaction. Either way they provide visitors something to hold onto. Personal speakers (Tourmate is a successful brand we observed) are recommended over headphones for sanitation, convenience, and to cause less antisocial behavior.</p>	

Portable audiovisual devices

Pros	Cons
<ul style="list-style-type: none">+ Audiovisual experience to visitors+ Guide visitors to inspect details+ Maps and navigation+ Several forms of activation (beacons, numbers, image recognition, etc.)+ Tell stories and include acting+ Enough content for entire visit+ Interactive experience+ Larger tablets used by families	<ul style="list-style-type: none">- Expensive devices- Only allow one user- Divert focus from objects- Headphone use can be anti-social- Require visitors to bring headphones- Non-headphone use creates noise- Little use by families with young children- Low usage rates unless given out- Difficult app installation and use- Visitors want to avoid screens- Maintenance and technical support
Recommendations	
<p>We do not generally recommend the use of portable audiovisual devices and apps. The use of personal audiovisual devices is inherently antisocial and distracting unless used very carefully. Devices and apps must enhance the experience through interaction with the exhibit and not just provide an experience that the visitor could have at home with the app. Specially protected tablets to help children guide families were the only overwhelming successful implementation we observed, and it must be remembered that many parents use museums to get their children away from screens. For a museum such as the WAM, the risk and cost of these devices could be prohibitive and audio tours or printed guides are much more feasible.</p>	
A note on beacons	
<p>Beacons are an exciting new technology for guiding and providing information to visitors based on locations. Beacons can be used with any portable devices, audio tours and audiovisual handheld devices. However, prototyping at several museums, some of which wished to remain unnamed, has shown beacon technology to be incomplete in its development. We do not recommend the use of beacons until they become more reliable and less expensive.</p>	

Audio stations

Pros	Cons
<ul style="list-style-type: none">+ Ease of use and simplicity+ Audio experience+ Visual focus on object+ Guide visitors to inspect details+ Tell stories and include voice acting+ Cheap and fast production+ Language selection+ Beneficial to sight-impaired+ Minor interactivity+ Very popular in museums targets towards families and children+ Easily used by groups	<ul style="list-style-type: none">- Noise pollution and distraction- Buttons may require a small amount of maintenance
Recommendations	
<p>We recommend the use of audio stations as providing another avenue for experiencing exhibits without distracting visitors from objects. They provide many of the same benefits of audio tours while also allowing group use. The tradeoff is that audio tours can provide hundreds of stops, which would be impractical with stationary devices.</p>	

Ambient noise

Pros	Cons
<ul style="list-style-type: none">+ Covers up noise distractions+ Relaxes visitors' fear of making noise/speaking in exhibits	<ul style="list-style-type: none">- Can itself become annoying
Recommendations	
<p>We recommend the use of some background noise such as music. Audio is already recommended in an exhibit as part of a multi-avenue approach to engagement. Ambient noise allows visitor to feel less self-conscious about using any other audio technology. However, due to the controversial use of ambient noise, testing is required.</p>	

Photography

Pros	Cons
<ul style="list-style-type: none">+ Ownership and take-home+ Appeal to both children and adults+ Break from the exhibit+ Inexpensive+ Group activity+ Visitors can use their own camera	<ul style="list-style-type: none">- Space requirements- Green screens can be complicated
Recommendations	
<p>We highly recommend providing an area for visitors to take pictures. This allows groups and families to take something home with them and provides a break from viewing the exhibits. We do not recommend the use of more complicated photography such as green screens or anything that requires an operator.</p>	

APPENDIX I: TABLET DEVELOPMENT PLATFORMS

Name Type	Cost	Development Language	Supported multimedia
Kiosk Pro Plus iPad app	\$40/device	HTML + CSS + JS	iOS supported
PhoneGap/Cordova Mobile development framework	\$0 (FOSS)	HTML + CSS + JS	iOS supported
Unity Cross-platform game engine	\$3000 or \$150/month	C#, JS	mp4 (video) mp3 (audio)
OpenFL Cross-platform library	\$0 (FOSS)	Haxe	External library
Xcode Official Apple IDE	\$0 (Freeware)	Objective-C, Swift	iOS supported
Ren'Py Visual novel engine	\$0 (FOSS)	Custom	mp4 (video) mp3 (audio)
LibGDX Cross-platform game engine	\$0 (FOSS)	Java	?
Xamarin Application development platform	\$0 (Mixed)	C#	iOS supported

Note: FOSS refers to Free, Open Source Software.

Note: iOS supported means that the platform uses iOS to handle media and therefore supports whatever forms of audio and video iOS supports

Individual Pros/Cons and Brief Description

PhoneGap/Cordova (<http://phonegap.com/>, <https://cordova.apache.org/>)

Pros	Cons
<ul style="list-style-type: none"> + HTML5 + Open Source (Free) + Many frameworks, workflows, IDEs, etc. + Web-based, published as a webpage + Highly popular 	<ul style="list-style-type: none"> - Can be “Incredibly Complicated” - Requires “Enormous amount of time” - Complex to set up - Too many framework options
<p>Apache Cordova is a free, open-source mobile development framework, originally produced by Adobe, that allows user to build iOS applications using web scripting. Adobe PhoneGap refers to the productized version and ecosystem built on top of Cordova. This includes a paired desktop and mobile application to abstract and streamline the process of creating and testing an application. It also includes a web service that allows users to build their applications for deployment to iOS, which has both free and paid versions.</p>	

Unity (<http://unity3d.com/>)

Pros	Cons
<ul style="list-style-type: none"> + Very easy to set up - “one click solution” + Many premade, baked-in solutions + One-button publishing with a variety of supported platforms + Large number of developers willing to answer questions on various forums and reddit + Large number of third-party addons to cover functionality not implemented in Unity API 	<ul style="list-style-type: none"> - Virtually no web-based support (not important if downloading app onto iPad) - Proprietary - Reliant on devs for bugfixes - Expensive if professionally used - Unity design increases the complexity of implementing some ideas
<p>Unity is a cross-platform game engine. It allows developers to create and test their applications in one simple development environment, before deploying them to multiple platforms. Unity allows individual developers and low-budget or low-profit organizations to develop for free. However, larger organizations and successful individual developers are required to purchase a license.</p>	

OpenFL (<http://www.openfl.org/>)

Pros	Cons
<ul style="list-style-type: none">+ Many tutorials+ Free (Flex IDE, Open Source tools)+ Open source tool(s) that allow compiling to multiple platforms+ http://www.openfl.org/	<ul style="list-style-type: none">- Cannot directly run on iPad. Must use Flash browser app or other solutions for packaging flash apps for distribution on iOS.- Test beforehand.- Can be complex to use
<p>OpenFL is an open-source library allowing user to develop flash applications and deploy them to many different platforms.</p>	

Xcode (<https://developer.apple.com/xcode/>)

Pros	Cons
<ul style="list-style-type: none">+ Official Apple IDE+ Free (Freeware)+ It is possible to publish directly to Apple device from IDE (but not to App store)+ Great integration with Apple's APIs and development process+ Simple to publish to iOS+ Can debug on iOS devices	<ul style="list-style-type: none">- Objective-C and Swift are different, stylistically, from other languages- Complex interface
<p>Xcode is Apple's official IDE for software development. It is well-integrated with their developer pipeline and environment. It is also usually a required step in building applications for iOS.</p>	

Ren'Py (<https://www.renpy.org/>)

Pros	Cons
<ul style="list-style-type: none">+ Very simple to use+ Free (Open Source)+ Custom scripting language designed specifically for visual novels+ Great for making interactive narratives	<ul style="list-style-type: none">- Limited focus- Experimental iOS functionality
<p>Ren'Py is a visual novel engine built using the Python language. It is scripted using a custom, easy to use language.</p>	

LibGDX (<https://libgdx.badlogicgames.com/>)

Pros	Cons
<ul style="list-style-type: none">+ Large variety of features (flexible)+ Free	<ul style="list-style-type: none">- Complex to use- No included IDE- iOS support currently in transition (previous iOS engine was recently discontinued)
<p>LibGDX is a popular open-source game development framework. It is written in Java and allows deployment to a large variety of different platforms. Currently, its iOS support is problematic as they are transitioning to a java engine for iOS. Their previous iOS engine was bought by another company and discontinued.</p>	

Xamarin (<https://www.xamarin.com/>)

Pros	Cons
<ul style="list-style-type: none">+ Easy to use for development+ Can develop and build for iOS on a windows computer+ Free to use	<ul style="list-style-type: none">- Complicated to setup build environment on windows (for iOS)- Requires setting up build to go through a Mac that does the final building
<p>Xamarin is an application development platform that allows user to develop mobile applications with one standard, familiar environment that can then be deployed to both iOS and Android. It wraps native APIs in a way that allows large amounts of code to be re-used between the iOS and Android variations of the application.</p>	

APPENDIX J: IPAD APPLICATION MANUAL

1. HOW TO SET UP THE APP

1.1. WHAT IS GUIDED ACCESS

Guided access helps the user to stay focused on a single task while using an iPhone, iPad, or iPod touch. Guided access limits the Apple device to a single app and allows control over which features are available.

1.2. SET UP GUIDED ACCESS

Tap Settings > General > Accessibility > Guided Access to access the Guided Access setup. Then, turn on Guided Access. With Guided Access on, set the passcode. This 4-digit pin will be used to prevent someone from leaving an active session.

Next, while still in Settings, tap General > Auto-Lock, then select Never to prevent the iPad from automatically locking the screen after a while.

You can adjust the display brightness under Wallpapers & Brightness.

1.3. STARTING GUIDED ACCESS SESSION

Once you have opened the Meyer Idea Lab kiosk application, triple-click the Home button to start a Guided Access session. Then, you can adjust the settings for the session before tapping start to return to the app with Guided Access enabled. The settings you can edit allow you to disable hardware buttons, touch screen input, and motion sensor input (eg. detecting device orientation).

1.4. END A GUIDED ACCESS SESSION

To end a Guided Access session, follow these steps:

1. Triple-click the Home button.
2. Enter the Guided Access passcode.

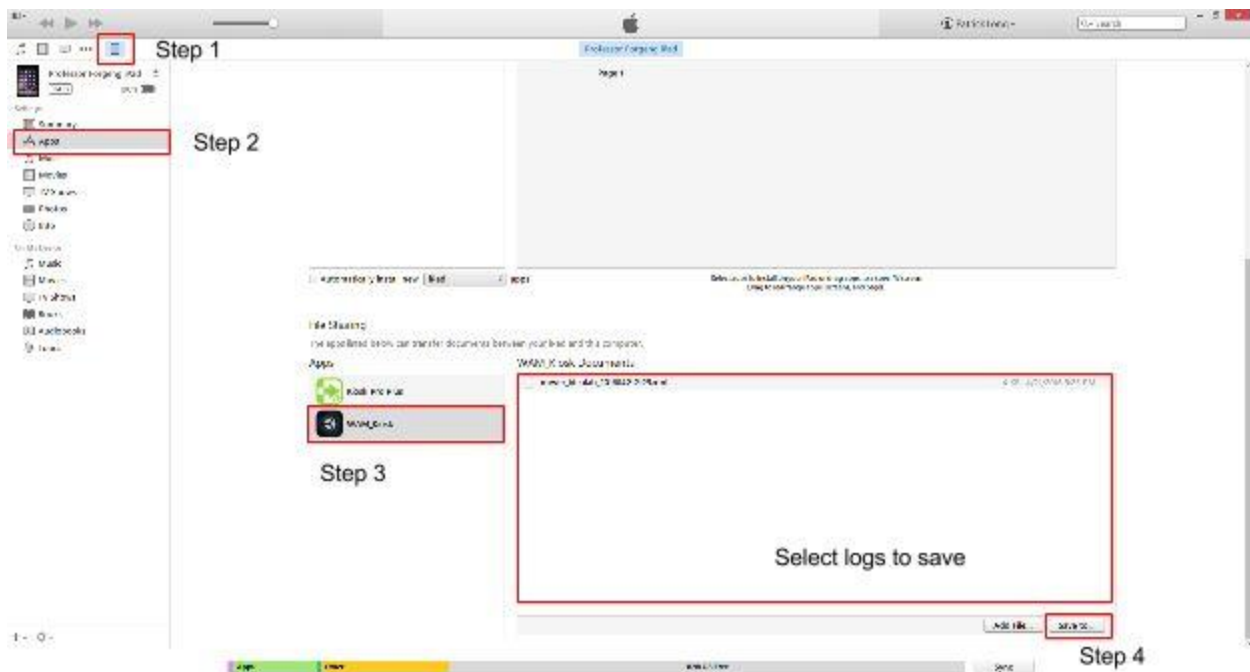
2. VISITOR TRACKING

The Meyer Idea Lab iPad app includes visitor tracking. It divides the actions of visitors by sessions, then pages, then actions. A session is the period from when the application leaves the start screen to when it times out and returns to the start screen. Page refers to how long the user spends viewing each individual page (main menu, slideshows, ...). On some of the pages, the app tracks further detail. These details are referred to as actions. In one of the slideshow presentations, an action refers to the visitor viewing a slide.

Periodically, the app saves its accumulated visitor tracking data to an xml file on the iPad, then clears the stored tracking data. These saved xml files can be accessed through iTunes and saved to the local computer for processing. Each saved xml file represents a roughly 2 hour period of visitor activity on the iPad.

2.1. READING THE TRACKING FILES

In order to access the tracking files, iTunes 12 is needed. Then, connect the iPad to the computer and open iTunes. In iTunes, navigate to viewing the connected iPad. Then, under Settings, select Apps. On this page, there is a section labeled File Sharing. In this section, there is a list of apps, select WAM_Kiosk, then select all the saved xml files and click Save To. Then, select the folder where you wish to save the xml logs.



2.2. TRACKING FILE FORMAT

Each individual tracking file is timestamped, to allow the Worcester Art Museum to analyze the data with the context of time. The format of the timestamp is in the format of Year.Month.Day.Hour

```

<SessionList>
  <Session length="347.7">
    <PageVisit length="79.9" id="game" />
    <PageVisit length="2.2" id="home" />
    <PageVisit length="31.5" id="meyer">
      <Action length="17" id="0" viewedPicture="True" />
      <Action length="5.6" id="1" viewedPicture="False" />
      <Action length="2.4" id="2" viewedPicture="False" />
      <Action length="6.5" id="3" viewedPicture="False" />
    </PageVisit>
  </Session>
</SessionList>

```

Walking through a portion of the tracking log, the total session lasted 347.7 seconds (5 minutes 47.7 seconds). The user first visited the game and played it for a total of 79.9 seconds (1 minute 19.9 seconds). Then, they returned to the main menu and waited 2.2 seconds before

deciding to view the *Life of Meyer* slideshow and did that for a total of 31.5 seconds. While viewing the slideshow, they first looked at the first slide for 17 seconds, also viewing the enlarged picture. Next they looked at slide 2 for 5.6 seconds, then slide 3 for 2.4 seconds, and finally slide 4 for 6.5 seconds.

- *SessionList* contains a list of individual sessions
- *Session* contains a list of individual page visits, *length* is the total length of the session
- *PageVisit* represents a singular visit by the visitor to one of the pages in the app, *length* is the total length of the visit to that page, *id* is the page's id
 - *home* = Main Menu
 - *meyer* = Life of Meyer slideshow
 - *longsword* = Fencing Longsword slideshow
 - *woodcut* = Explore the Woodcut
 - *swordplay* = Swordplay Demonstration
 - *game* = Art of Combat Game
 - *flipbook* = Illustration Flipbook
- *Action* represents an action performed while visiting the page, this provides a finer level of detail, but is not included for all the pages
 - For the slideshow pages (*The Life of Meyer* and *The Fencing Longsword*), *Action* represents a visit to a slide. *length* is the length of time spent viewing the slide. *id* provides the slide number and starts at 0. *viewedPicture* tells whether the visitor discovered the Easter Egg and viewed the enlarged image

- For the woodcut page (*Explore the Woodcut*), *Action* represents a viewing of one of the woodcut items. *length* is the length of time spent viewing the item. *id* provides the id of the item and is in the form *item_{a-l}*.

NOTE: All times are measured in seconds

2.3. WOODCUT KEY

