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Evolution of the Museum Experience: Mobile Augmented Reality's Impact on the Visitor Experience at an Outdoor Living Museum

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Evolution of the Museum Experience: *Mobile Augmented Reality's Impact on the Visitor Experience at an Outdoor Living Museum*

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A Thesis submitted in partial fulfillment of the requirements for the degree of

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Capstone Committee:

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Committee Approval

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Committee Chair / Advisor

Bryan French – Lecturer — Date

Committee Member

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ABSTRACT

This paper reports the findings of a study to determine if using Mobile AR (augmented reality) to render an exhibit's supplemental information increased the level of learning and enjoyment of visitors to a living museum, specifically the Pocock Trail located within the Bergen Swamp, which is classified as a "Living Museum". A museum is identified as "Living" when it "is a natural, wild area that is relatively undisturbed by man. It is an area where the native plant and animal life are maintaining themselves in a natural, biological manner" (BSPS, 2016). When an area is undisturbed by man it is not possible to add traditional text-based exhibit descriptions on plaques or posters. AR adds digital content to the real world that visitors can interact with in the same manner that they interact with the physical world. It is used to evoke emotion, to tell a story, or to document an event (Craig, 2013). AR was used to augment the real world of the Bergen Swamp to add supplemental information that was viewed on a mobile device. The goal of this study was to determine whether the use of AR technology would enhance a visitor experience to this living museum compared to a traditional guided tour by a docent. Visitors were first provided a docent to guide them through the Pocock trail, and then the same visitors were provided an app to download which used an AR browser to guide them through the same trail.

General Terms

HCI, Human factors

Author Keywords

Docent, Mixed reality, Living museum;

Keywords

Augmented Reality, Cultural Heritage, HCI, Immersive experience, Mobile Computing, Museums, Tourism

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INTRODUCTION

Living museums have challenges when it comes to presenting supplemental information about their exhibits because nature is the exhibit and living things are temporal. AR (augmented reality) is a low-cost, reliable and interactive means to provide visitors with supplemental information about the exhibit and enhance the visitor experience. AR adds digital content to the real world that visitors can interact with in the same manner that they interact with the physical world. It is used to evoke emotion, to tell a story, or to document an event (Craig, 2013). Although AR technology has been used in museum exhibits, my research is unique in that I intend to use this technology in a living museum, not a traditional museum. The exhibit is located in the Bergen Swamp, chartered in 1936 by the New York State Board of Regents as a "Living Museum" (BSPS, 2016). This research seeks to discover if using mobile AR offers visitors an engaging experience that is informative and enjoyable.

This research will examine whether using AR to present supplemental information material for an exhibit is a viable alternative to the trail guide docent, who is responsible for presenting the supplemental information verbally to the visitors. In a living museum, where nature is the exhibit and living things are temporal, the flowers are in bloom for only a few weeks, animals move in and out of the area, some of the birds migrate, and plants go dormant. Because of this, not all of the living things in the exhibit the trail guide docent is presenting are visible to the visitor. The trail guide docent can only show visitors what is in view at the time and must verbally describe everything else. The visitor must rely on the description the trail guide docent provides and his or her own knowledge. AR can provide the visitor with supplemental information on demand. The material can include text, links to additional material, pictures and videos of the living things.

Thus, the use of AR can show the visitor the vegetation and wildlife that are not visible at that moment due to seasonal dormancy or animal migration habits.

BACKGROUND

AR has seen an evolution of definitions since its beginning in the 1960's (Kipper & Rampolla, 2013). For over 50 years now AR has grown from using expensive, bulky head-mounted display devices to small, mobile and affordable devices. The AR of today uses Open Source Software, making it available to everyone. Developers from all over the world contribute to AR features that in turn are given back to the community. As the devices changed over time, becoming smaller and affordable, so did the definition of AR.

Augmented Reality

AR technology has its roots in interface research done as far back as the 1960's, in the early days of computer science. Movies have made AR familiar to audiences since the 1980's with 1984's "The Terminator" or 1987's "RoboCop" (Mullen, 2011). But few are familiar with the 1962 motorcycle simulator "Sensorama" (Heilig, 1998), designed by cinematographer Morton Heilig. Its multi-sensory technology included visuals, sound, vibration, and smell. Sensorama (Figure 1) stands as one of the earliest examples of immersive and multisensory technology.

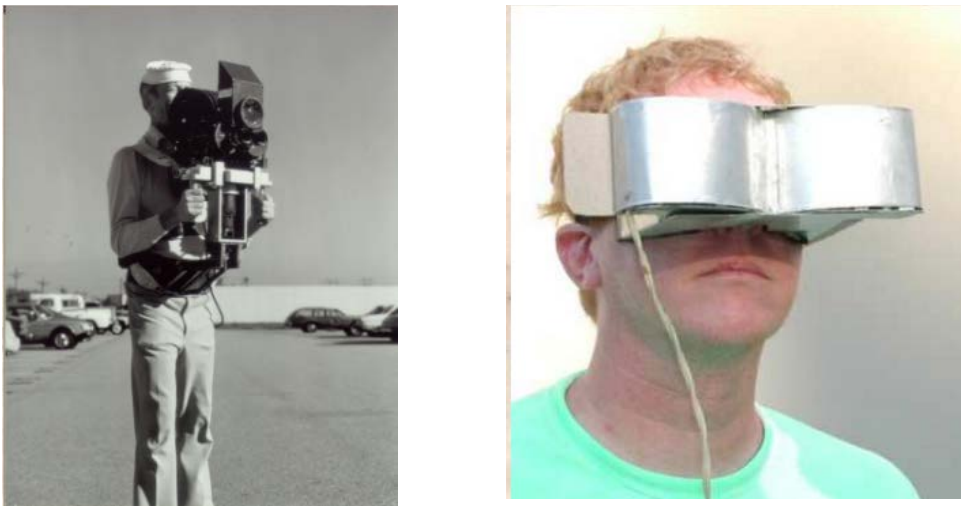


Figure 1: Sensorama Projector and Telesphere Mask
(http://www.mortonheilig.com/InventorVR.html)

In 1968 the first AR and VR system called “The Sword of Damocles” (Figure 2) was created by Ivan Sutherland (Sutherland, 1968). “Sutherland was one of the earliest to use six degrees-of-freedom (6DOF) trackers; where the body is free to move forward and backward, up and down, left or right and can rotate over the three perpendicular axes” (Videogames, 2014).

Figure 2: 1968 The Sword of Damocles
(https://www.youtube.com/watch?v=ISJWZpFIAlQ)

1990’s

By the 1990’s AR had made significant advances, but the bulky and expensive head-mounted display devices kept the technology out of reach for most users. In 1996 Jun Rekimoto developed an AR prototype called NaviCam (Sony CSL, 2017) that advanced the 2D matrix marker (Figure 3). A marker is what identifies the place where digital information is to be presented. This type of marker is still in use today.

Figure 3: naviCam (Rekimoto & Nagao, 1995)

The definition of AR has evolved since the early 1990’s when it was typically defined as the opposite of VR (Virtual Reality). In 1993 Wellner, Mackay and Gold defined AR as “the use of computers to augment objects in the real world instead of using computers to enclose people in an artificial world” (1993). The virtuality continuum proposed by Milgram states that augmented reality is just one expression of a mixed reality, which combines real and virtual (Milgram, Takemura, Utsumi, & Kishino, 1994).

By the late 1990’s AR began to be defined on its own. In the 1997 paper “A Survey of Augmented Reality” Ronald T. Azuma asserted that there were three characteristics that defined augmented reality:

- Combines real and virtual

- Interactive in real time
- Registered in 3D

(Azuma, 1997)

By 1999 AR had three significant events to move it forward. Beginning with Total Immersion, the first company to become the augmented reality solutions provider when in 1999 it released D'Fusion (Total Immersion, 2015). They continued their research and development of D'Fusion for the next decade which established them as a market leader in augmented reality. Next came the ARToolkit, a suite of tools that allowed for video capture of the real world to be combined with 3D virtual objects. Hirokazu Kato released the ARToolKit (ARTOOLKIT, 2017) to the open source community making it accessible to a wider audience of designers and developers. The third major event took place in 1999 when Hollerer, Feiner, and Pavlik developed a wearable AR system MARS (Mobile Augmented Reality Systems) that let users experience AR information that was integrated with relevant outdoor locations. This system was a prelude to the AR browser. (Columbia University, 2017)

2000's

In the early 2000's AR made advances into gaming, education and tourism. In 2000 Bruce Thomas et al. created an AR version of the popular game Quake. "AR-Quake" (Figure 4) "was a first-person augmented reality view of the game which incorporated a six degrees-of-freedom (6DOF) tracking system, GPS, a digital compass, and vision-based marker tracking" (ARQuake , 2010).

Figure 4: ARQUAKE

In 2001 Reitmayr and Schmalstieg (Reitmayr, 2001) created a mobile, multi-user AR system. (Figure 5) This design showed the potential for AR hybrid systems by combining mobile augmented reality and collaboration capabilities between users in a shared augmented reality space.

Figure 5: A user wearing the mobile augmented reality kit

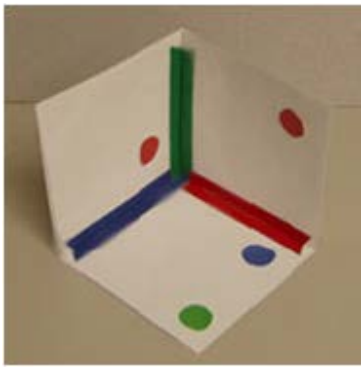
"Archeoguide" (Figure 6) created by Vlahakis et al., is an AR system for tourism and education. Archeoguide was built around the historical site of Olympia, Greece, and contained a navigation interface, 3D models of ancient temples and statues, and avatars competing in a run. (Vlahakis, et al., 2001)

Olympia without AR

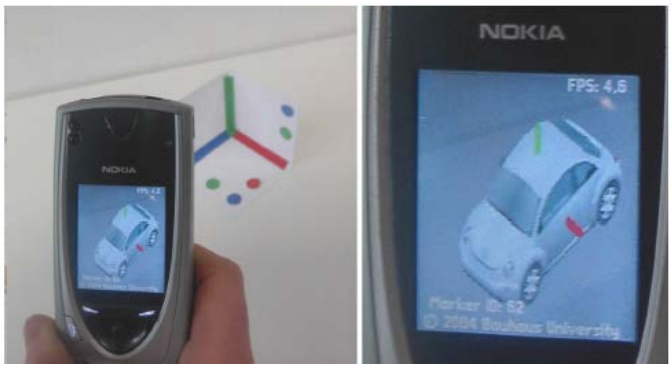
Olympia with AR

Figure 6: Archeoguide

The Real-World Wide Web (RWWW) Browser created by Kooper and MacIntyre is recognized as the first AR Browser. This mobile system acted as an AR interface to the World Wide Web (Kooper & Blair, 2003). By the mid 2000's AR started to go mobile. In 2004 the first system for tracking 3D markers (Figure 7) on mobile phones was presented by Mathias Möhring (Möhring, Lessig, & Bimber, 2011). The development allowed for the detection and differentiation of different 3D markers and the integration of 3D renderings into a live video stream. This work showed a first video see-through augmented reality system on a consumer cell phone.



Three dimensional marker



Video see-through example on a consumer cell-phone

Figure 7: Optical Tracking and Video See-Through AR on Consumer Cell-Phones

In 2006 Nokia initiated the Mobile Augmented Reality Applications (MARA) (Greene, 2006) project (Figure 8). The research project experimented with creating an AR guidance application

using the multi-sensor functions in mobile phones. The prototype superimposed an image stream captured by the camera and marked the users surrounding in real time with graphics and text.

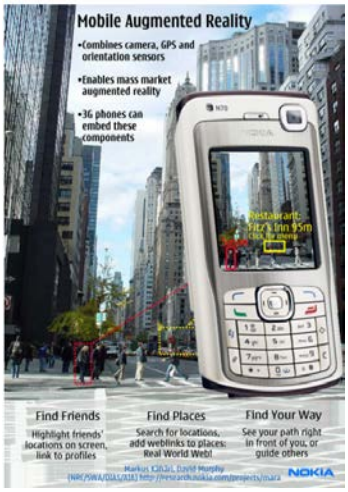


Figure 8: Mobile Augmented Reality Applications (MARA) (Ma soupe 2.0, 2008)

By the late 2000's, AR browsers became mainstream. In 2008, Mobilizy launched the Wikitude World Browser with augmented reality (Breuss-Schneeweis, 2009). This application combined GPS and compass data with Wikipedia entries and overlayed information on the real-time camera view of a smartphone (Figure 9).

Figure 9: Wikitude AR Travel Guide (Joos, 2008)

In 2009, SPRXmobile launched Layar (Lens-FitzGerald, 2009). Layar is another AR browser that uses GPS and compass data for registration. Layar uses an open client-server platform and

content layers, which is an AR browser equivalent of traditional Web pages on a PC-based browser (Kipper & Rampolla, 2013).

Today's AR

In 2013, Craig identified that the following as key aspects (ingredients) of augmented reality:

- The physical world is augmented by digital information superimposed on a view of the physical world.
- The information is displayed overlaid with the physical world.
- The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world.

(Craig, 2013)

An example Craig gave was

> *to imagine for a moment that you have a child who loves dinosaurs. For a present you want to bring a T. Rex to the back yard. Using technology to create an augmented reality experience you can add a T. Rex to your backyard. Your child and friends will be able to walk around the T. Rex and see it from the front, side and back. The T. Rex is not static either, you can make it so the T. Rex walks around your back yard, sniffing the ground for the scent of dinner. This experience is possible using an Augmented Reality mechanism.*

AR is a medium used to alter the real world around you. AR is a new medium that can tell a story. Traditionally, storytelling has been done orally or on paper with words and pictures or in a play or movie where actors reenact the story. Alan, in *Understanding Augmented Reality: Concepts and Applications,* defines AR as "Augmented reality is used to tell a story, to evoke emotion, or to document an event" (Craig, 2013). Craig's definition is what I will use for this paper.

> *the core essence of an augmented reality experience is that you, the participant, engage in an activity in the same physical world that you engage with whether augmented reality is involved or not, but augmented reality adds digital information to the world that you can interact with in the same manner that you interact with the physical world. . . . consider it that you are engaged in the regular normal world, but there are additions to that world that consist of digital information that is placed in the world to augment the world with things you would not normally see, hear, feel, touch, etc.* (Craig, 2013).

Often AR is confused with VR (Virtual reality). However, AR is not VR. VR will completely immerse a user inside an artificial environment, and while immersed, the user cannot see the real world around him (Kipper & Rampolla, 2013). In contrast, AR is taking digital information and superimposing this information in the real world. If the experience does not occur in the physical world, does not have a digital modification to the physical world, and is not interactive, then the experience is not an AR experience. Movies, such as "Jurassic Park" and "Avatar" that feature digitally generated content in the real world are not AR because they are not interactive. An image modified to show a dinosaur in your backyard is not AR because it is not interactive.

Alternately, an image of a cartoon character named Ratta (Pokémon Go, 2016) superimposed in in the real world directly in front of you (Figure 10) is AR because you can interact with it.

Figure 10: Ratta from Pokémon Go

There are many forms and types of technology that can be used to create an AR experience. But the technology is not what makes AR memorable; it is the story or experience with AR that makes AR memorable. This is typical for most stories. For example, the paper a story is written on does not make the story more or less memorable. The story of Moby Dick is memorable whether it is on 20 pound paper or 24 pound paper. It is also just as memorable whether it is video in a .mov format or .mp4 format. It is the actors' performances, recreating the story, that make it memorable.

AR has continued to grow in advertising, navigation and sightseeing. Disney's campaign 'Disney Characters Invade Times Square' has people stand in a marked circle opposite the billboard, and a Disney character magically appeared and interacted with people as they watched on the big screen (Russell, 2012). This was most likely intended to draw in children, but became a hit with adults sword fighting Captain Hook and dancing with Cruella De Vil (Figure 11).

Figure 11: Disney Characters Invade Times Square

With Lego Fusion (figure 12), when an object is put on top of, under, or next to a tablet, a version of it will appear in the app (Robertson, 2014).

Figure 12: Lego Fusion

A big use and continued potential for augmented reality is navigation. City guides such as Yelp (wikiHow, 2017) and NRU (pronounced "near you") which help people find places to eat, drink, and shop, have augmented reality capabilities that give users real-time visual directions to the places they are looking for (Dahlström, Lewis Jones , & Balabanovic, 2010).

Another application called TapNav (Sorrel, 2011) uses AR to overlay your route on the road ahead. The visual benefits to this are immediately obvious as you can quickly see where you are supposed to be going with easy visual cues (Figure 13). However, there is a problem with this concept due to the danger associated with looking through a mobile phone while driving.

Figure 13: TapNav

AR is perfect for an enhanced sightseeing experience. By unlocking hidden and interesting information that is all around, the tourist, sightseer, or academic will have the chance to explore the unique details of a place. One AR application specifically designed for tourism is called "Tuscany + Augmented Reality" (Barbara, 2010) which brings up points of interest for the traveler in Tuscany (Figure 14).

Figure 14: Tuscanny

Today, an important aspect in defining augmented reality is that you "remain" in the physical world. All your senses will pick up cues from the real world. You will hear, see, smell, taste and touch the physical world around you in the same way you would if there were no AR. With AR there is never an attempt to make you believe you are not in the real world. AR's definition has evolved as it moved from expensive, large, head-mounted devices that kept the technology out of reach for most users; to compact, portable and inexpensive mobile devices that put it in reach of users.

Museums

Traditional Museums

The ICOM (International Council of Museums) statute, in reference to the international community, defines a museum as:

> *A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment.*

This definition was adopted by the 22nd General Assembly in Vienna, Austria on August 24th, 2007 (ICOM, 2007). This paper will refer to these types of museums as traditional museums. Museums like the Metropolitan Museum of Art in New York City, the Smithsonian National Museum of Natural History in Washington DC and the Rochester Museum and Science Center are examples of traditional museums. Traditional museum exhibits are in a physical structure such as a building with electricity, running water, indoor plumbing and indoor heating and cooling systems.

Living Museums

A museum is identified as "Living" when it "is a natural, wild area that is relatively undisturbed by man. It is an area where the native plant and animal life are maintaining themselves in the natural, biological manner. A place where one may still see nature and learn some of her lessons and secrets" (BSPS, 2016).

The Bergen Swamp is one of many museums in New York State designated as a living museum. The Bronx Zoo in New York City and the Genesee Country Village and Museum (GCV&M) in

Mumford, New York are living museums. The Bronx Zoo has relocated live animals into display exhibits, and the Genesee Country Village and Museum has relocated historic structures to a common site and provides live persons enacting life in these older homes, factories & churches (Locke, 2016).

Living museums are often confused with Nature Clubs. Nature Clubs, such as the Sierra Club or the Rochester Garden Club are not a museum. They are good educators and help develop a public awareness for nature, but they do not hold any artifacts for display (Locke, 2016). Several of the large environmental land trusts, such as The Nature Conservancy (The Nature Conservancy, 2017), are also not living museums. They are private land holdings that often restrict visitors.

Bergen Swamp Living Museum

The BSPS (Bergen Swamp Preservation Society) was chartered by the NYS Board of Regents as a living museum. A provisional charter was approved in 1936 and the absolute charter was approved in 1944 (Slifer, 1960). Unlike all other "Living Museums" chartered in NYS, the Bergen Swamp's exhibits are not acquired and moved to a single display location for the visitor. Rather, the BSPS allows the "visitor" to access the single location where the plants and animals can be observed in their original ecosystem. The BSPS provides the visitor access into the living museum on the corded, or wood plank, trails the BSPS constructed and maintains (Locke, 2016).

The inventory of the collections and artifacts located in the Bergen Swamp took decades to identify. The botanists that surveyed our Bergen Swamp from 1910 to 1950 created our

curatorial list. These botanists include Walter C. Muenscher, Paul A. Stewart, William D. Merrell, Babette I. Brown, Arland T. Hotchkiss and many others. The exhibits placed on display are the plants, fungi, and animals that can be seen and heard along marked trails. The exhibits not on display are off trail (Locke, 2016).

The BSPS (Bergen Swamp Preservation Society) founding committee, led by Mary Slifer in 1936, petitioned New York State for a provisional charter to begin this collection. But to obtain the permanent charter, the BSPS had to demonstrate that it had an adequate facility and the resources to acquire the space necessary to assemble, catalog, preserve and exhibit its collections (Slifer, 1960). The BSPS had not purchased any property at the time of the provisional charter. Not until five years after the provisional charter, in 1941, did the BSPS trustees, led by Dr. Richard Goodwin, close on the first BSPS land purchase, a five-acre parcel in the Bergen Swamp for $125. This initial purchase provided the first "room for exhibitions, and an environmental space to store that portion of the collections not on exhibit." Three years later, in 1944, New York State granted a permanent BSPS charter. At this time the BSPS had purchased several hundred acres of the present 2,000 acres of the Bergen Swamp (Locke, 2016).

Similarities between Traditional and Living Museums

Traditional museums and living museums both have a similar purpose, obligation, displays, restrictions, and curators. Their purpose is to enable people to explore collections for inspiration, learning, and enjoyment (Flude, 2008). Their primary obligation is to assemble, preserve and interpret its collection. Both museums own a collection of artifacts that are on display for the visiting patron. Both have exhibits open to the public, and restricted areas that only the curators

are allowed to access. In a traditional museum, if a visitor were to enter the restricted area, or back room, without permission, they would be confronted as a trespasser and potential thief. In the Bergen Swamp, a living museum, visitors who venture off trail without permission are also confronted as trespassers and potential thieves (Locke, 2016). The restricted areas exist to ensure the safety and sustainment of the collections. It is the responsibility of the curators who manage and care for these collections and artifacts to ensure they are preserved for future generations to enjoy.

Another similarity a traditional museum and a living museum share are docents. A docent is a trained volunteer who "translates, decodes … explains or describes exhibits" (Grinder & McCoy, 1985). Museums and cultural sites have increasingly been turning to computers and mixed reality in particular to augment their educational and interpretive efforts (Rayward & Twidale, 1999). Today, visitors to the Bergen Swamp are led down the trail by a certified trail guide docent. The docent has two roles, safely guide the visitor down the trail, and act as a docent teaching the visitor about the various plants, flowers, fungi, and animals at each exhibit.

Differences between Traditional and Living Museums

The primary difference between a traditional museum and a living museum is the type of exhibit on display. Traditional and living museums have different types of exhibits that a curator is responsible for. In a traditional museum the curators will manage and care for collections or artifacts that are items on display. The collections can be rotated at predetermined times and even exchanged with other museums. In a traditional museum, the curator can change the exhibits by removing or adding an artifact to the collection. In a living museum, the curator will manage and

care for a collection of living artifacts. The curator does not rotate the collation or exchange the collection with other museums. Nor does the curator change the exhibit by removing or adding living things. However, in a living museum the living things in the collection are free to move on their own accord. In addition the exhibit can be altered by events not caused by humans, like predictable forces, such as weather and seasons, or unpredictable forces, such as drought, fire, or flood.

RELATED WORK

Technology in Museums

Earlier I defined museums based on the ICOM statute.

> *A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment.*

However, recently traditional museums have become places of leisure and are now challenged with designing appealing exhibits for large numbers of visitors while maintaining and conserving exhibit artifacts. “To handle this challenge they have turned to technology to help achieve a balance between leisure and learning, to help them be more effective in conveying story and meaning” (Sparacino, Davenport, & Pentland, 2000). Research has shown that when technology is easy to learn, it can aid in visitor social integration and aid in utilizing small spaces efficiently. Technology that does not match the visitor’s mental model will be difficult to learn for most visitors.

Some studies have been successful in integrating technology, while others have not. One common theme to successfully integrating technology with a museum exhibit is that it must be easy to learn, easy to use and enjoyable. Rebeca et al was successful in their study of the impact that an electronic guide book vs a non-electronic guide book had on the visitor experience because it was easy to learn how to use. Their system, Sotto Voce, a guidebook designed to support social interaction between visitors and their companions, had a high rate of adoption and

visitor enthusiasm. “The successful adoption suggested that after little instruction, typically lasting between two and three minutes, the guidebook was easy enough to use that almost everybody found a way of incorporating it into the visit” (Grinter, et al., Nov 2002).

Integrating technology into the museum experience that satisfies both the needs of the curator, who needs to show a large amount of material in a limited space, and the visitor, looking for an articulate narration of the display, was achieved by an exhibit called Unbuilt Ruins. Unbuilt Ruins shows a variety of architectural designs by the 20th-century American architect Louis Kahn. “The exhibit interactively featured computer graphics renderings of eight unbuilt masterworks by Louis Kahn” (Sparacino, Davenport, & Pentland, 2000). Visitors would congregate around a table and position a cursor on a hot spot which would project the selected architecture onto large screens surrounding the visitors (Figure 15). This exhibit was successful at using technology to fit a large amount of material in a small space and make it easy to learn and enjoyable for the visitor.

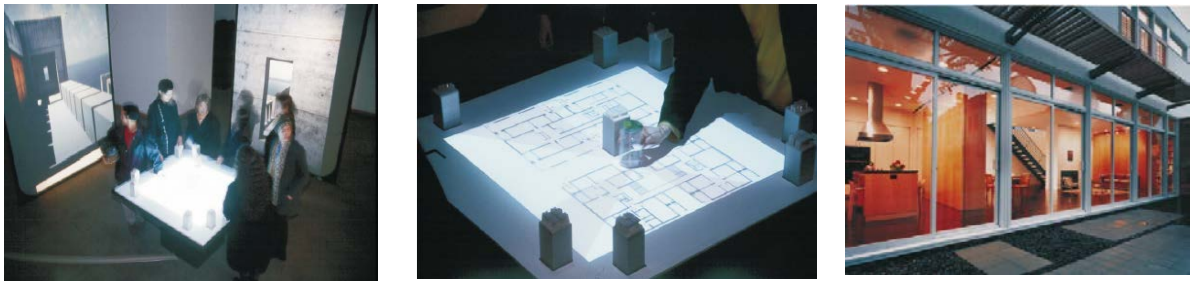


Figure 15: Unbuilt Ruin

One challenge to successfully integrating technology with a museum experience is when visitors have a preconceived and inaccurate mental model of the technology. Hsi and Fait custom-designed an RFID application called eXspot. It was prototyped and evaluated for three years at the Exploratorium, a hands-on science museum in San Francisco. The eXspot system let visitors

capture information about the exhibits they visited and take souvenir photographs while at the museum. They discovered that using RFID technology to make exhibits interactive or to collect content was not well understood by museum visitors.

> *Even though bookmarking was a recognized feature in art museum audio tours and on the Internet, museum visitors have a relatively undeveloped mental model of what RFID technologies are and how they work. The most daunting barriers to adoption of RFID systems in museum settings are the visitors' own societal and educational expectations*

(Hsi & Fait, September 2005).

Technology can successfully help museums manage large crowds of people if it is easy to learn, easy to use, and provides the visitor with an enjoyable experience. Technology that does not work in the same way as the visitor's mental model can be a challenge for visitors to adopt (Hsi & Fait, September 2005). If visitors arrive with an assumption that the technology will be used in a way that it is not used, they will struggle with it because they will subconsciously return to using it according to the preconceived notion they have of how it works. Overcoming visitors' preconceived and inaccurate expectations of how technology works is a challenge curators must overcome when integrating technology with museum exhibits (Hsi & Fait, September 2005).

Balancing Technology and Nature

One of the Bergen Swamp Preservation Society's charter is to encourage research and educate the public about the lands owned by the society (BSPS, 2016). Building the AR exhibit in the Bergen Swamp is an example of using technology to help educate large crowds of people. This includes visitors from nearby schools, conservationists and the casual visitors. Research by Tallon and Walker found that

> *museum visitors learn more, and are more inclined to contribute and share, when their activities are concentrated on specific subjects and on a limited number of objects or exhibits. It appears that, for school groups and for casual groups of visitors, more structure and narrower scope seem to contribute to greater learning as well as increased incentive to participate*
> (Tallon & Walker, 2008).

It will be important to ensure that the Bergen Swamp AR exhibit has the right balance of AR technology that complements the visitor experience and does not distract the visitor from the beauty of this natural habitat.

Research by Ciolfi and McLoufhlin recommended Museums consider alternatives to using mobile devices.

> There is a need to consider solutions alternative to mobile devices only, as certain limitations of mobile technology have been highlighted – isolation, detachment from the setting – and could be overcome. Mobile devices alone might cause people to detach themselves from the exhibits, and often the mobile content provided is disconnected from the place
> (Ciolfi & McLoufhlin, 2010).

The space and beauty of the natural landscape between exhibit stations will result in visitors spending more time enjoying nature. Using mobile devices in a large museum like the Bergen Swamp should not be a distraction to visitors because the exhibits are far apart. Visitors will be using the mobile device for a small amount of time, but in that time the AR technology will make an impact that significantly and positively effects the visitor's experience.

Most of the exhibit is the nature landscape itself. As visitors walk through the exhibit, there will be the smell of flowers and songs from birds, complimented by intermittent interruptions from

the frogs, as well as the beauty of nature. As visitors journey through the exhibit, the Mobile AR will be supplementing the overall exhibit experience to ensure the visitor has a complete experience. Ciolfi and McLoufhlin point out that "Open-air museums offer an interesting environment for the consideration of how mobile personal devices could be used in synergy with standalone interactive installations and information points to provide a more seamless visitor experience: to not have visitors concentrate only on the mobile device, but to keep the focus on the site" (Ciolfi & McLoufhlin, 2010).

It is also essential that the exhibit compliment the current experience visitors have and not introduce competitive or unattractive out of place technology. To achieve this, the AR markers are discoverable, designed to be aesthetically pleasing, and compliment the natural surroundings. In the paper "Designing for Meaningful Visitor Engagement at a Living History Museum" Ciolfi and Mcloughlin describe how their use of technology (Reminisce) successfully enhanced visitors experience in the Folk Park exhibit.

> "*Reminisce did not incorporate competitive elements into the trail, nor a fixed structure that the participants had to follow. Rather, it was a flexible complement to the experience of the Folk Park, a subtle guide that would enrich the visit at appropriate times and places without introducing unsightly technology within the buildings, rather by adding a digital layer through augmented objects that would integrate with existing displays in bringing the site to life and in facilitating visitor engagement"* (Ciolfi & McLoughlin, 2012).

The AR technology in the Bergen Swamp exhibit since May 2016 has been designed to fit into the landscape, yet also be discoverable and engaging. It is optional and is designed such that each exhibit station will provide an engaging experience.

AR in Museum Exhibits

The use of AR to create an interactive exhibit in traditional museums is gaining ground in the research community. Researchers have explored interactive exhibits using ubiquitous displays with augmented reality (Bowers, et al., 2007) and virtual reality (Brown, et al., 2003). There are also case studies on interactive technologies in museums by (Grinter, et al., Nov 2002) and (Sparacino, Davenport, & Pentland, 2000). However, using AR in a living museum to create an interactive exhibit has not been studied. Studies at Cultural Heritage sites have been done and provide guidance for what could be successful in a living museum.

While the literature is full of studies for traditional museums, there is an understanding of the possibilities that exist for using immersive technology in non-traditional museums. As Ciolfi and McLauglin point out, “there is a need to extend current theoretical and practical approaches to guide such design interventions when considering sites that are spatially distributed and that are structured in ways different from the traditional one-room, one exhibit approach typical of traditional museums” (Ciolfi & McLoufhlin, 2010).

AR in Cultural Heritage Sites

There are two studies that provide the basis for the mobile AR model proposed for the Bergen Swamp exhibit. The first is *ARCHEOGUIDE Reconstructing Ancient Ruins* with AR and the

second is *Mobile Augmented Reality for Interpretation of Archaeological Sites*. Both rendered a 3D reconstruction of ruins using AR. These studies are the model of how AR can be used for exhibits in the Bergen Swamp.

The ARCHEOGUIDE (Augmented Reality-based Cultural Heritage On-site GUIDE) system uses AR to reconstruct ruins (Vlahakis, et al., 2001). Reconstructed monuments are rendered in 3D like the one shown in Figure 16. Users considered it a useful learning tool that enhanced their visit. The user's enthusiasm was encouraging and users wanted to see it at other cultural sites.

Olympia without AR

Olympia with AR

Figure 16: Archeoguide AR reconstruction of Olympia

Similar to ARCHEOGUIDE, Arbela Layers Uncovered (ALU), a mobile AR system for the ancient site of Arbela, Iraq, also used AR to restore ancient ruins (Mohammed-Amin, Levy, & Boyd, 2012). In the study *Mobile Augmented reality for interpretation of Archaeological sites,* Mohammed-Amin, Levy, & Boyd created ALU to help visitors interpret archeological sites that are partially or fully buried or in ruins. This study addressed the design of navigating through a mobile interface, which is a challenge for designers when so much content is required. The study "discusses the development of a proof-of-concept and the design decisions involved. ALU

features media for guiding visitors and interpreting and presenting the complex and multifaceted history of the site" (Mohammed-Amin, Levy, & Boyd, 2012).

Figure 17 shows the main menu interface which loads with the camera view activated and is divided into three partitions; a status bar at the top, a camera view in the center, and content buttons down the left side for History, Heritage, and Database.

Figure 17: The ALU's main interface components viewed against Arbel citadel.

Figure 18 shows the History mode, where historical information can be accessed for the 7000 year history of the Arbel site. The content in this mode is not augmented (Mohammed-Amin, Levy, & Boyd, 2012).

Figure 18: ALU's interface when a historic event is activated in the History mode.

Figure 19 shows Heritage mode: the three-dimensional AR view of the site along with relevant information.

Figure 19: An augmented three-dimensional view in the Heritage mode.

Figure 20 shows a map with the user's location and the surrounding content plotted with pins. The size of the pins changes to convey the user's proximity to a map location. This view allows the user to see a bigger picture of the historic site and its contents geotagged to it.

Figure 20: A view from the Heritage map view, which shows corresponding content for an activated pin on the map.

The mobile AR design proposed in this study is a good starting point for future AR apps that not only reconstruct 3D imaging, but also provide supplemental information to aid in understanding the sites.

Docents in Mixed Reality

In the research *Operation Citadel: Exploring the role of docents in Mixed Reality*, the authors describe the role of docents in a mixed reality game at a historic site called Operation:Citadel (Yule, MacKay, & Reilly, 2015).

> *The docents act as intermediaries between the system and the participants, providing interpretation and understanding of the game and managing interaction. This permits the integration of sophisticated interactions and rich narrative while maintaining the walk-up-and-use, casual nature of the exhibit. We … examine the effect that docents had on enjoyment of and frustration with the game. Our results indicate that docents can serve an important role in augmenting participant experience.*

They recognized that mixed reality experiences are challenging from a technical, logistical, and immersion based standpoint, and docents can help address these problems. In their research they described docent roles in mixed reality experiences as,

1. Have the docent be a part of the event's world
2. Ensure docents understand all parts of the system: technical, gameplay and intended experience
3. Allow docents to break character when necessary.
4. Have a docent if you will have a group or a crowd to mediate and facilitate social interactions, answer crowd questions, and engage a crowd in the activity of other participants.
5. Ask docents to point out correspondences between the augmented world and the real one. For example, point out landmarks in the virtual world and their corresponding location in the real world.

(Yule, MacKay, & Reilly, 2015)

They also point out the limitations of a docent.

> *Ideally the docent should nudge visitors along. But sometimes time constraints cause a docent to push visitors along at pace not comfortable for the visitor. Docents are a limited resource, and must be trained prior to the event. Without a good understanding of the system, they will not be able to fill in holes in the experience pyramid. Furthermore, there should be at least one docent per group, meaning that the number of simultaneous groups becomes limited by the number of available docents. This is less of an issue when a MR event relies on performers who are independent of any group.*

(Yule, MacKay, & Reilly, 2015)

Such is the case with the docent and AR in a living museum. The docent tells a story that is enriched by AR with images, alternative links to maps, history, sounds, videos or an interactive recreation of extinct animals and landscapes. Without AR the docent can only tell visitors about the extinct mastodon that used to live in the area. With AR the docent can show the visitors a mastodon which they can interact with as the docent tells visitors about them.

BERGEN SWAMP AR EXHIBIT PROJECT

The Bergen Swamp AR Exhibit is a 2 year project that will include three types of AR implementations to enrich the visitor experience.

1. Vision AR, which uses a marker to locate the AR content. Vision AR has been in the Bergen Swamp since May 2016.
2. Geo AR, which uses latitude and longitudinal coordinates to locate the AR content.
3. 360 degree, AR which can use either a marker or latitude and longitudinal coordinates to locate the AR content.

AR will be used to show exhibit artifacts in a living museum that are not available or visible because of natural dormant or migration cycles and give visitors the full immersion into all the artifacts the exhibit has regardless of their availability. AR will provide an immersive experience into the geology of the Swamp thousands of years ago. AR will bring the Mastodon back to the Bergen Swamp where visitors can watch it graze on grass, watch the baby mastodons play and even see an adult mastodon charge.

Research using interactive technologies outdoors in a large living museum like the Bergen Swamp has not yet gained ground. In the same manner that AR can reconstruct ruins in a Cultural Heritage site, it can also reconstruct living things, so they can be viewed year round by visitors to the living museum. Plants, such as fern, fungi and orchids, which are only visible at certain times of the year, will be viewable all year long using AR. The study for this research

applies only to the Vision AR. Yet Vision AR is just 1/3 of experience planned for the Bergen Swamp. This section provides an overview of the full project.

Vision AR

Vision AR is based on Layar's 'Layar Vision'. Layar Vision uses detection, tracking and computer vision techniques to augment objects in the physical world (Layar, 2017). It can tell which objects in the real world were augmented because the fingerprints of the object are preloaded into the application. For this study, the object is referred to as a "marker". When a visitor aims their mobile device at a marker that matches the fingerprint, Layar will return the associated AR experience.

Vision AR will provide visitors of the Bergen Swamp with supplemental information. The Vision AR technology will be designed to be discoverable and optional since, according to Tallon and Walker, "visitors do not always go to a museum with an explicit or specific goal in mind, visitors desire a mix of structure and freedom" (Tallon & Walker, 2008). It is important to ensure that the AR technology compliments the exhibit and does not interfere with the visitors' freedom to roam.

The Bergen Swamp is a natural habitat with trails in various states of repair. Some trails are well marked with well laid boards to walk on. Other trails are overgrown with no boards or boards in need of replacement or repair. Maintenance of trails is done by volunteers and sometimes damage due to weather and age outpace the rate at which the volunteers can keep up. With

Vision AR markers and the AR entity associated to it can inform the visitor of the trail condition as well as navigation.

Guiding the Visitor

Using AR objects is a cost effective way to provide visitors with more than just navigation, but also information that is necessary for decision making, such as deciding whether or not to continue because of the trail's difficulty, safety, or level of experience required. Many of the trails are safe in the summer, fall and winter but may be considered unsafe or dangerous in the spring, depending on the amount of storm damage and flooding in the area during the spring thaw. The AR content can be changed in minutes to keep visitors up to date on trail safety (see Figure 21).

Figure 21

Keeping visitors informed of where they are could also be accomplished with AR entities (Figure 22). Guiding visitors through a living museum that is exposed to all the forces of nature in upstate New York presents many challenges that do not exist when designing navigation

methods through a traditional museum. AR will provide visitors the information they need to navigate safely and confidently.

Figure 22

Educating the Visitor

Vision AR will be used to educate visitors about the various types of life in the exhibit. Because the exhibit is a nature preserve, the artifacts are viewable to visitors only at certain times of the year. For example, the Bergen Swamp is home to rare orchids, some of which bloom every 10 years for only a few days. Vision AR can put this rare blooming orchid on exhibit every day of the year. Markers will be used to show the location of AR entities that will educate the visitor. The AR entity will be a presentation using an image, movie, slideshow and or text that describes the exhibit.

AR is an innovative way to expand the museum's contribution to one's existing knowledge and leave the visitor with an experience he or she is likely to remember. Research on visitors of

traditional museums by Tallon and Walker has sought to remove the stereotype that a visitor "connotes passivity" or someone who visits a collection owned by a museum, then goes away (Tallon & Walker, 2008). For most museums, the accepted view of a visitor is that of "constructivist"; that knowledge is "actively produced by a learner, focusing not on what an individual learns but on what the museum contributes to his or her existing knowledge" (Tallon & Walker, 2008). Using Vision AR in a living museum gives the museum a medium to present exhibit supplemental material and aid in the knowledge the visitor acquires.

Geo AR

Geo AR markers use latitude and longitude coordinates to identify the location that a Geo AR entity will be revealed. Geo AR entities will superimpose graphics or animation in the environment to create an immersive experience of a much bigger scale.

Geo AR entities will also be used to show visitors what an area in the swamp looks like in a different season. For example, Figure 23 shows a person standing in the same location in the Bergen Swamp that the AR entity is displaying. The difference is the person is standing in the location in August when the swamp is dry and the AR Entity is showing the Bergen Swamp in the spring time when it is flooded. Most people are physically not capable of getting to some are areas in the spring time because of the level of water. AR gives the visitor the immersion into that spring time perspective without getting wet or stuck in a bog.

Figure 23

Geo AR will also give visitors a moment in time where they are immersed in the past viewing extinct plants, mammals, birds, and reptiles. Figure 24 shows an example of an AR entity that superimposes a mammoth grazing.

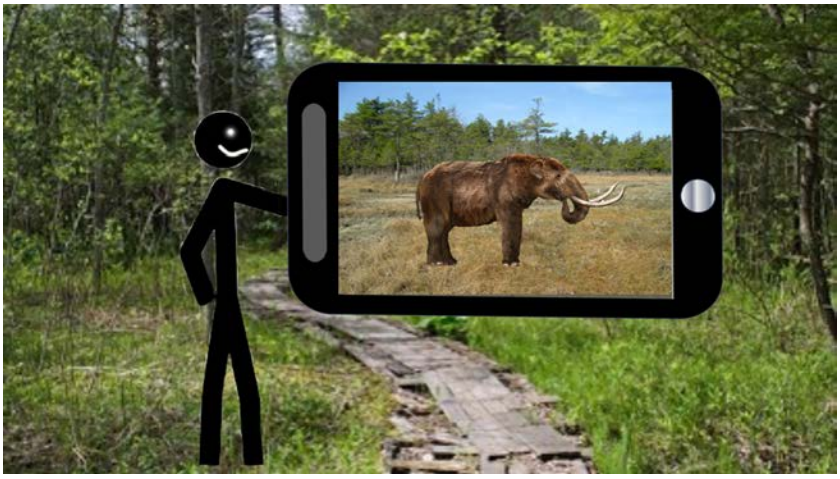


Figure 24

A challenge with GEO AR that will need to be overcome is the precision of the rendering. One of the hurdles with GEO AR system is to attain close registration with the real world so that the AR rendering is placed in the physical world to very close tolerances. The tightness of the tolerances depends on the application. For example, with the mastodon example, it may be okay

if the registration is off by a few yards because the mastodon is so large. However, if a small dragon fly was rendered, then an error of a few yards it may result in the visitor missing the rendering.

360 degree AR

The term 360 degree AR superimposes an environment surrounding the user, allowing them to see an augmented environment in the 360 degrees around them. Research by Morrison, Gu and Foulcher in the paper “Applying augmented reality to Preserving Industrial Heritage” proposed using 360 degree AR technology to preserve the cultural heritage of Newcastle Australia. Since 1801 Newcastle was a manufacturing and engineering based city. In the 1980’s -1990’s the “need for modern industrial sites and the spread of housing developments resulted in the reduction of the older manufacturing sites. There was a need to find a way to preserve this heritage and Morrison, Gu & Foulcher proposed using AR” (Morrison, Gu, & Foulcher, 2013).

They researched an “interactive AR application that would give an insight into the history and development of Newcastle that visitors would not be able to get with any other media. Even if the same images were in the Museum they would not give the visitor the same depth of understanding as experiencing the image in situ and see the changes through the different eras” (Morrison, Gu, & Foulcher, 2013).

Figure 25 is an image from the paper and is a Photoshop mock-up of a coal pit at Merewether which is now a suburb of Newcastle with no industry. The visitor can experience the area all around them.

Figure 25

Figure 26 shows what the area looked like in the 1900's loading coal. The modern image shows industry on the north side of the harbor while the south side is a harbor promenade lined with cafes and restaurants.

Figure 26

The authors concluded that while both this project and AR technologies are in their infancy, the technology has great potential to assist as a tool for architectural historians (Morrison, Gu, & Foulcher, 2013).

The Bergen swamp exhibit will use 360 degree AR to immerse the visitor into the landscape of the swamp thousands of years ago. For example, the Bergen Swamp was once covered by a glacier. 360 degree AR can show visitors what the area looked like when it was covered by a glacier, see Figure 27.

Figure 27

METHODOLOGY

The purpose of this research is to understand if using mobile AR to view the supplemental information of a living museum exhibit affects the visitor experience. Visitor experience will be measured by enjoyment and learning. This research addressed the following questions.

1. Does Mobile Augmented Reality technology applied to museum exhibits increase the level of enjoyment for visitors in a living museum?

2. Does Mobile Augmented Reality technology applied to museum exhibits increase the level of learning for visitors in a living museum?

In order to answer these research questions, a controlled experimental study was performed to determine if AR is responsible for increasing the level of enjoyment and learning. The experiment was conducted with two conditions. The first condition was experiencing five of the ten Pocock trail exhibits with the non-AR method of a trail guide docent to verbally deliver supplemental information. The second condition was experiencing five of the ten Pocock trail exhibits using the AR method of mobile AR to receive supplemental information.

Location

The exhibit is located on the Pocock trail in the Bergen Swamp, Figure 28.

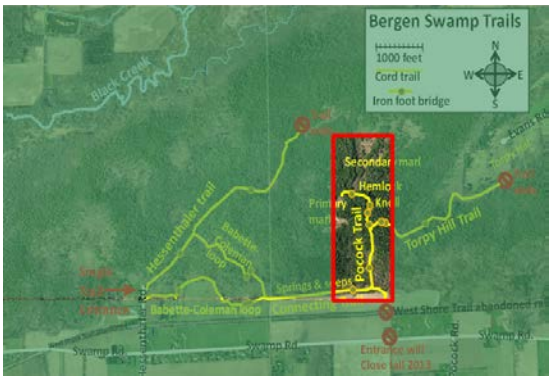


Figure 28: Location of the Pocock Trail in the Bergen Swamp

Figure 29 shows the location of the ten exhibit stops along the Pocock trail. These ten exhibits are not accessible in February when this experiment was done. So the ten exhibits were moved to an indoor office setting and exhibit markers were placed on walls in the hallways, Figure 31. The relocated exhibit will be referred to as the auxiliary Pocock trail.

Figure 29: Location of the 10 exhibits on the Pocock trail

Exhibit AR Content

Before the experiment could be conducted, the Exhibit material from the docent-led tour needed to be written down. The current trail guide docents have years of knowledge about the Pocock trail and currently do not use supplemental material. They all share an outline of material to be covered, but each trail guide docent delivers a slightly different message.

To ensure consistency, the ten exhibits were recreated digitally using Microsoft PowerPoint 2013. This undertaking was significantly under estimated and required the assistance of the Bergen Swamp Preservation Society. President Steve Locke standardized the message for each exhibit to include the following sections:

- You are here
- History
- Trees
- Birds
- Soil
- Plants
- Research (past or present) conducted at the site

Figure 30 shows the supplemental material content created for Exhibit 1. For the docent led portion of the experiment the trail guide docent used the content from this material for their verbal delivery of supplemental material at each exhibit. The trail guide docents were allowed to add content but were not allowed to remove content.

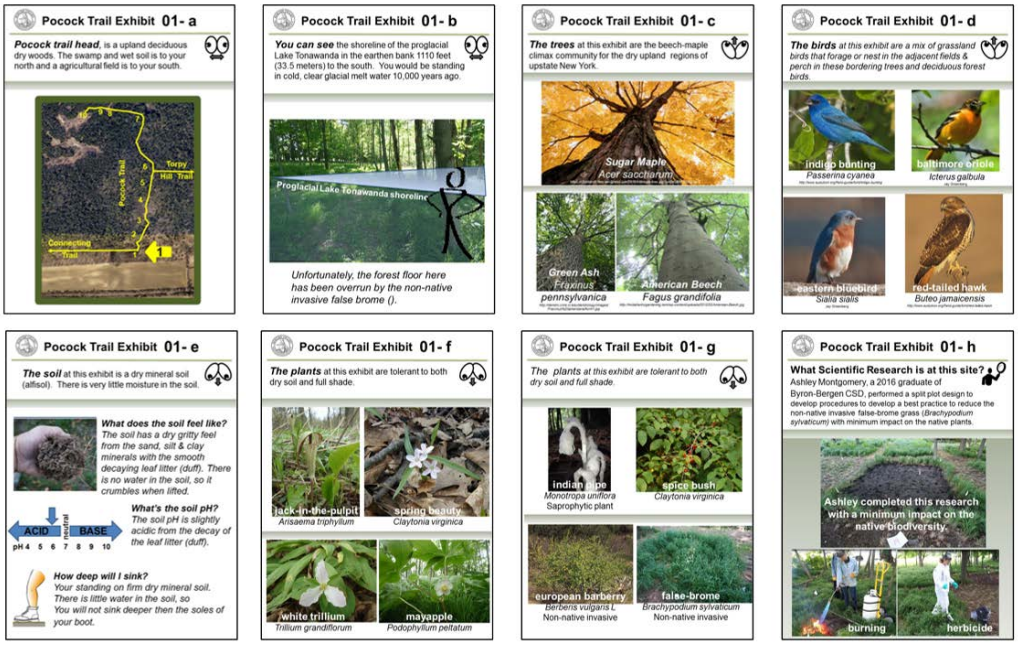


Figure 30: Exhibit 1 AR supplemental information

The content was deliberately designed to be minimal and static. If the content was overloaded with different types of media, such as movies, sound, animation, it could negatively disrupt the visitor experience. For example, adding sound could become too much of a distraction for visitors. The objective was to have participants evaluate the supplemental material delivery method and not the supplemental material itself.

Human Subject Clearance

In accordance with RIT policies, permission to conduct the study was obtained from the Institutional Review Board (IRB), Appendix D, prior to collecting any research data. The permission was for both the qualitative and quantitative data. All participants signed an informed consent form, Appendix E, before being allowed to participate in the study.

Research Design

The study used a mixed methods design to strengthen the study findings. It started with a quantitative method, using online surveys, followed by a qualitative method of semi-structured interviews, a ranking survey for future enhancements and open-ended questions regarding what would make the exhibit better. The research used a within subject design. One group of participants tested both methods of supplemental information: the non-AR method of trail guide docent and the AR method using AR.

Procedure

The study began with a pre-study introduction in the Lilac conference room, Figure 31. A pre-study script, Appendix F, was used to ensure a consistent introductory message was given to each group. After the pre-study introduction, participants were given a practice AR target to learn the technique of rendering the AR content.

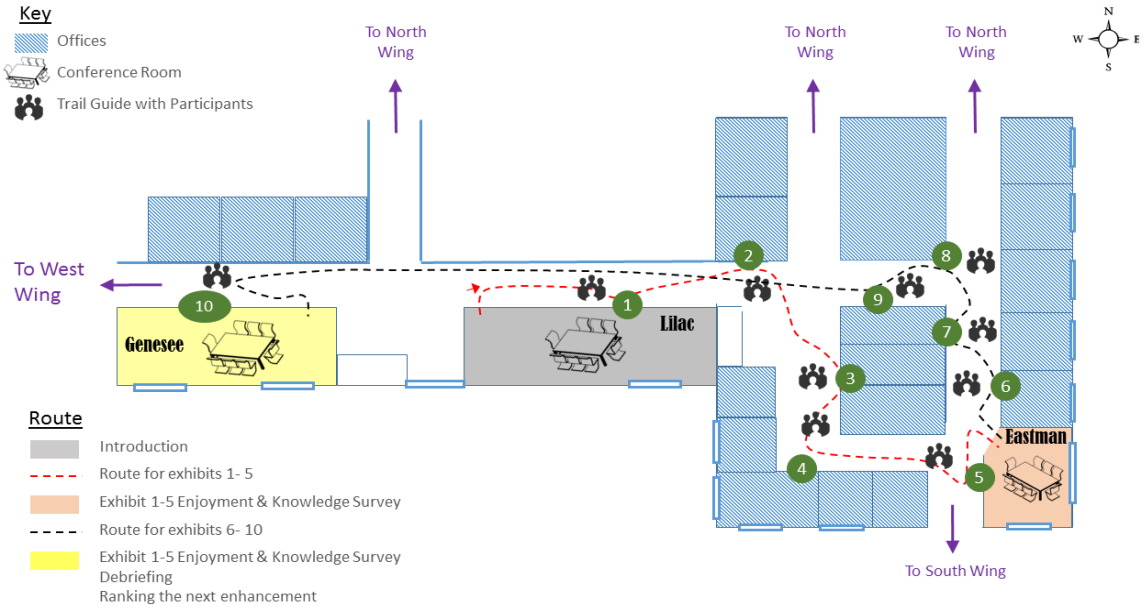


Figure 31: Auxiliary Pocock trail layout

Participants were shown the AR markers located in the hallway on their trip through the 10 Exhibits. A vision AR marker, Figure 32, was placed at each of the 10 exhibit stops on the auxiliary Pocock trail. These vision markers are unique to each exhibit and determine the AR content, Figure 30, rendered to the visitor.

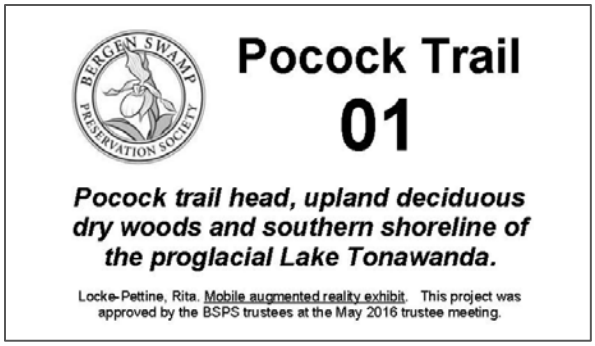


Figure 32: Visions AR Marker for Exhibit 1

Using a mobile device camera with the Layar's (Layar, 2017) augmented reality browser, visitors launched the Layar browser and put the AR marker in the camera's view finder. Once the target was in the browsers view, the participant tapped the screen. After tapping the screen Layar performed a scan of the target marker. A spinning icon displayed in the browser for a few seconds and then the target had an animated rippling or wave motion to indicate to the participant that it was downloading the AR content, Figure 33. This ripple effect provided the participants with a visual cue that the tap they made had launched the search for the AR entity associated with the target.

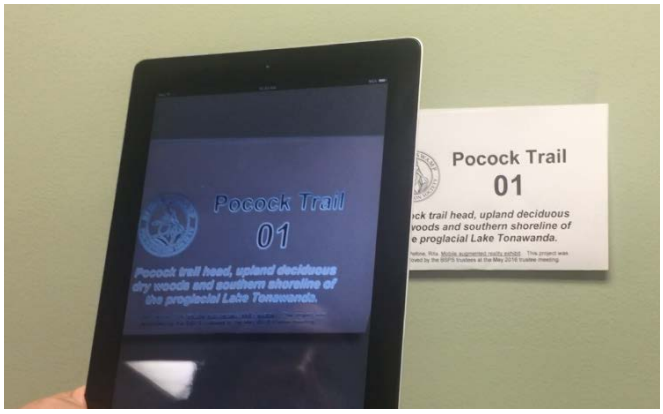


Figure 33: Layar scanning the target

The Layar browser then processed the AR marker and rendered the AR content on the screen, at which time the visitor could move away from the target and interact with the slideshow by swiping the screen to navigate through the slide show, Figure 34.

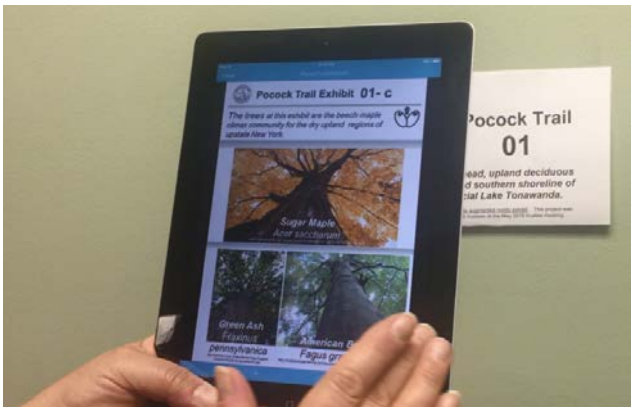


Figure 34: AR slideshow

After the participants completed the pre-study tasks, they were introduced to the Bergen Swamp Preservation Society certified trail guide docent who would lead them down the auxiliary trail as though they were on the real trail. To help participants feel as though they were on the real trail, the trail guides dressed in the clothes they would wear if they were in the Swamp. For example, they wore knee-high rubber muck boots.

The participants would experience 5 exhibits with the non-AR method and 5 exhibits with the AR method. Participants who came in as couples were allowed to share a device, since this is how they would view the AR content if they were on the actual Pocock trail. To prevent confounding the order in which the participants experienced each method, the order was counterbalanced by having one participant flip a coin to randomly determine the order. If the coin toss was heads, exhibits 1-5 used the non-AR method and exhibits 6-10 used the AR

method. If the coin toss was tails exhibits 1-5 used the AR method and exhibits 6-10 used the non-AR method.

The auxiliary exhibit route is marked in Figure 31. After Participants finished with exhibits 1-5, they stopped in the Eastman conference room to complete an interest and enjoyment survey, Appendix G, and a knowledge survey, Appendix H. After the surveys were completed, participants continued on with the trail guide docent through exhibits 6-10. After completing exhibits 6-10, they stopped in the Genesee conference room to complete an interest and enjoyment survey, Appendix G, and a knowledge survey, Appendix H.

The trail guide docent was with the participants through all 10 exhibits, including the exhibits where participants used the AR method to render the supplemental information. When on the Pocock trail visitors are always with a trail guide docent to ensure the group's safety and this rule was enforced for the experiment on the auxiliary trail. The trail guides are certified by the BSPS in safety procedures and educational material. They stayed with the visitors at all times to ensure that the visitors stayed on the trail and followed the right path to the next exhibit. The trail guides docents are knowledgeable in the history of the exhibit, living things in the exhibit, research that is ongoing or has been done in the past, and folklore. Two Bergen Swamp Preservation Society trail guide docents volunteered their time to assist with the study.

For the 5 exhibits the trail guide docent did not act as a docent, they continued to lead the visitors down the auxiliary Pocock trail, stopping at each exhibit where participants used the AR browser

to learn about each exhibit. The trail guide docent was allowed to answer questions the participants had, but were not allowed initiate a discussion.

When the participants finished with the10 exhibits, they were debriefed in the Genesee Conference room, Figure 31. They were allowed to discuss their experience in their own words and ask questions to the trail guide docent, the researcher and other participants. The researcher took minutes from each debriefing.

After the debriefing, participants were presented with posters containing mock-ups of future enhancements and the researcher provided a brief description of them. A survey listing additional features that could be added to enhance the AR exhibits was given to each participant to rank, Appendix I, in the order they would like to have them completed. The purpose of this survey was to understand what should be worked on next. The survey also had open-ended question asking participants what they thought would make the exhibits better.

Participants

Twenty seven participants, 11 male and 16 female, were recruited from RIT, members of the Bergen Swamp Preservation Society, friends and family. All participants were 19 years old or older. Sixteen participants were 50 years old or older and 2 participants were between 40 and 49 years old. Five participants were between 30 and 39 years old and 5 participants were between 20 and 29 years old. Of the 5 participants between 20 and 29 years old 4 were college students and 1 had graduated 2 years prior to the experiment. Only 1 participant in the 30 - 39 age group had visited the Bergen Swamp.

Two methods for participant recruitment were used, a recruiting flyer and recruiting email. The flyer in Appendix A was used to advertise the experiment, however no one responded to the flyer. The recruiting email, Appendix B, is what brought in all the participants. All 27 participants were recruited from emails sent directly to them or from emails forwarded to them by others.

Participants were screened, Appendix C, based on their familiarity with using the camera on a hand held device. They were not required to own a device. If they did not have a device or did not want to use their own device, one was provided for them. Knowing how to use the camera on a handheld device was required in order to use the AR Browser. The AR browser uses the device's camera to locate the AR target. The user then taps the screen to initiate the scan. For this experiment, it was determined that someone with no knowledge of how to use a camera on a handheld device was too novice to participate in this study.

Instrumentation

The study collected both qualitative and quantitative data. Quantitative data was collected using the online survey tool Qualtrics. Qualitative data was collected using a semi-structured interviews and open-ended questions. The qualitative data measured interest and enjoyment, Appendix G and knowledge, Appendix H. The interest and enjoyment survey was copied from Ryan and Deci. In 2000, Ryan and Deci published *Self-determination theory and the facilitation of intrinsic motivation, social development and well-being* in the American Psychologist Journal (Ryan & Deci, 2000). Because interest and enjoyment is very subjective and difficult to measure

the instrument Ryan and Deci developed was used for this experiment to ensure that a reliable and established method of measurement was used. Their method used a Likert scale to measure interest and enjoyment. Learning was measured by a multiple choice quiz. Exhibits 1-5 had a quiz and exhibits 6-10 had a quiz. The quiz questions were created by the researcher and pulled from the exhibit material. For both the interest and enjoyment survey and the learning survey participants marked the method used; AR or non-AR.

Qualitative data was collect in a semi-structured debriefing session. To start the debriefing discussion the researcher ask “Now that you have experienced both methods of receiving supplemental information what are your thoughts and feeling regarding them?” The researcher took notes of the discussion that followed. Following the debriefing discussion participants were given a brief overview of the possible enhancements to the exhibit and then provided with a survey to rank them, Appendix I. This survey also included open-ended questions about what they thought would make the exhibit better

Analysis of Data

Qualitative data for the interest and enjoyment and learning was collected using an online survey tool called Qualtrics. When the online survey closed, data was exported into Excel 2013 and analyzed according to the type of question in the survey. The results were described using both descriptive and inferential statistics. The interest and enjoyment analysis used a Wilcoxon Signed-rank test to compare the AR method and non-AR method scores that came from the same participants. The knowledge analysis used an independent sample *t* test to compare the differences in means between the groups to determine if there was a statistical significance

between results. In all tests for statistical significance, the level of significance was $\alpha = 0.05$ and the confidence interval was set at 95%. The data collected during the debriefing was transcribed and divided into themes.

RESULTS

In this section the quantitative analysis of interest and enjoyment and learning is presented along with the qualitative data from the debriefing session, ranking survey and open-ended questions.

Interest and Enjoyment

The purpose of the interest and enjoyment survey, Appendix G, was to answer this question.

1. Does Mobile Augmented Reality technology applied to museum exhibits increase the level of enjoyment for visitors in a living museum?

Hypothesis Testing:

H0 = Using mobile augmentation for exhibits at a living museum will not increase the level of enjoyment for visitors in a living museum?

H1 = Using mobile augmentation for exhibits at a living museum will increase the level of enjoyment for visitors in a living museum?

The median of the AR method was 42.5 and the non-AR method was 43. They were not significantly different per the Wilcoxon Signed-rank test. The scores were not statistically different. (W=137, N=26, Z=-0.6861) p>.0-5. Thus, the null hypothesis could not be rejected.

Learning

The purpose of the knowledge survey, Appendix G, was to answer this question.

2. Does Mobile Augmented Reality technology applied to museum exhibits increase the level of learning for visitors in a living museum?

Hypothesis Testing:

H0 = Using mobile augmentation for exhibits at a living museum will not increase the level of learning for visitors in a living museum?

H1 = Using mobile augmentation for exhibits at a living museum will increase the level of learning for visitors in a living museum?

An independent sample *t*-test was conducted to compare the differences in means between the AR method and non-AR method and determine if there was a statistical significance between results. The level of significance was a= 0.05 and the confidence interval was set at 95%.

For each participant the sum of all the correct responses was scored. Participants provided more correct responses using the AR method (2.9615, SD = 0.9992) than using the non-AR method (Mean = 2.0000, SD = 1.4697), $t(50) = 2.7587$, $p<.05$, two tailed. Therefore the Null hypothesis was rejected.

Qualitative data

Qualitative data was collected in the debriefing session that occurred after participants completed the interest and enjoyment survey and knowledge survey for exhibits 6-10. To start the debriefing discussion the researcher asked "Now that you have experienced both methods of

receiving supplemental information, what are your thoughts and feeling regarding them?" The researcher took notes of the discussion and divided the results into themes.

Theme 1: The best experience uses both methods

The overall consensus was that visitors wanted to have both the trail guide docent and AR supplemental information. The AR supplemental material let visitors consume information at their own pace and allowed them to see the things, such as dormant flowers, that were not visible. The interaction with the trail guide docent made the exhibit engaging for visitors. They enjoyed the enthusiasm and storytelling method the trail guide docents used to present exhibit supplemental information. They also enjoyed the immediate feedback to questions they asked of the trail guide docent.

Below are comments from participants

1. "I would like a combination of both. (Trail guide docent and AR) I liked when Steve (Trail guide docent) talked to us and I like the pictures. I would like to have the pictures while Steve is talking."
2. "I like being able to ask questions." (in reference to the Trail Guide)
3. "I want to be able to ask questions (in reference to the Trail Guide) after viewing the AR."
4. "However with an app you can ask a question but do not get feedback." (in reference to how the docent can provide immediate and accurate feedback)
5. "Lee's (Trail Guide) enthusiasm makes it more enjoyable."

6. “Having a conversation is much better for the primary source of information, AR is a secondary source of information.”
7. “I would like Steve (Trail Guide) to narrate after I get done reviewing the material.”
8. “I would like a combination of visuals and verbal.”
9. “I liked the reading and then being able to discuss it with Lee. (Trail Guide)”
10. “I want to be able to see the material and ask questions.”
11. Two participants did not want the trail guide docent to verbally describe the exhibit at the same time they were reviewing the AR content. Their concern was that when others asked the trail guide docent a question they could not always hear the answer and they wanted to hear the response. They felt it was too difficult to listen to the response at the same time they were reviewing the AR content.

Theme 2: Participant feedback about the learning survey

The majority of participants did not like the survey for measuring learning. Many were vocal about this while taking the survey for the first time after exhibits 1-5. Interestingly, none of the participants in the 20-29 age range commented on the learning survey. Not commenting does not mean they liked the survey. It most likely means that they are accustomed to taking tests in their college studies. The most vocal participants were in the 40 and above age range. One group with participants in the 50 and over age range refused to move on to exhibits 6-10 until they had the correct answers to the questions given to them. The trail guide docent provided the group with the correct answers. After learning the correct answers the researcher witnessed some of the participants changing their answers to the correct ones. The researcher intervened and confirmed that only the original answers were submitted.

Below are comments from participants

1. “I interacted more with the visuals but retained more from the verbal. I learn what I am interested in, like the birds. I don’t care about the fungi.”
2. “I learn by asking questions.”
3. “Taking a quiz is not how I learn.”
4. “Casual museum visitor will learn in a casual manner. They learn things but only retain what interested them.”

Theme 3: Enhancements and information design changes

The participants’ enthusiasm during the debriefing was well received by the volunteer trail guide docents who encouraged the participants to make honest comments. The participants praised the exhibit and were eager to give feedback on what they thought could make the exhibit better.

Below are comments from participants

1. “Let the visitor know what is up ahead before I move to the next stop so I know what to look for while on the way.”
2. “Group is dependent on the trail guide, I would like to be able to go back on my own and pick a topic.” (this is referring to a target version of just birds, just plants, etc)
3. “Use 1 picture per page, I could not zoom in.”
4. “Hard to tap on target, can that be easier?”
5. “More on the relationship of Lake Tonawanda and the American Indians.”
6. “More information on golden root herb.”

7. “Add bird songs. I want to be able to learn how to recognize the birds by their calls.”
8. “Do not add background sounds of the sight, I am in the swamp I will hear the noise.”
9. “Add 3D graphics of the processes that happen in the swamp.” (such as showing the breakdown of material over time or showing the glaciers receding. The point being 3D would bring these things to life)
10. “I want to be able to get more information.” (a link to another web page with more information)
11. “Make specific to an area, birds or plants etc.”
12. “I could not go back and look at previous information. I would rather have an app so I can go back.”
13. “I would like it to be like the northern American bird app, must be easy to use.”
14. “Add 360 degree for all of the seasons to each stop.”

Many of the participants were experiencing mobile AR technology for the first time and made suggestions that either a mobile app or using QR codes would be a better method of delivering supplemental information.

Enhancement Ranking

The enhancement ranking survey, Appendix I, was given to participants after the debriefing session and after a brief overview of each enhancement. Mock-ups of the 360^{o} view of Lake Tonawanda and the glaciers was presented. Mock-ups of a mastodon and pterodactyl simulated in the swamp using 3D animation and GEO AR was demonstrated. Showing what the swamp

looked like in all four seasons was also presented with mock-ups. Chart 1 shows the results of the ranking survey.

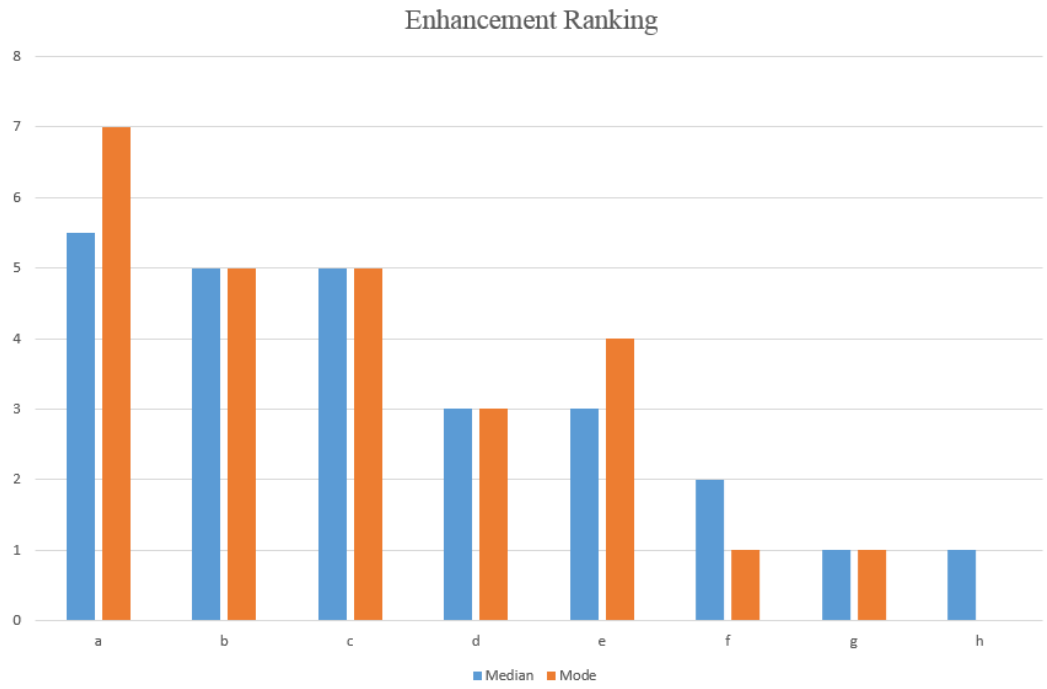


Chart 1: Ranking Survey

Key:
a - Add narration or the option for narration of the slides
b - Use 360 degree augmented reality
c - Use GEO augmented reality
d - Include natural sounds at each exhibit
e - Add three dimensional objects
f - Show a docent in 3D narrating an introduction to the exhibit
g - Show video of the path from one exhibit to the next
h - Include a Link to web pages with more information

The enhancement Ranking survey also contained 2 open-ended questions. The researcher wanted to give participants the opportunity to provide feedback anonymously. Table 1 shows participants responses to the 2 open ended questions.

Open-ended questions

Participant	What can we do to make this experience better?	Is there anything else you would like to tell us?
1	I think you are on the right path, no pun intended.	
2	gift shop (truck)	get colleges involved
3	Interactive augmented reality with 3D plants and animals. Audio	include wine
4	A free app with the data already on it to prevent the need for internet connections	scanable QR codes might work better
5	offer a portable version -Bring the swamp to schools, senior living centers, festivals, etc.	I recommend have the same device for all Provide option to rent the device on self-guided tour
6	Uncle Steve as my guide	Zoom in on the pictures in the AR, especially the maps
7	Add bird songs at each exhibit Time lapsed photography	
8	Include audio (birdsongs) Larger pictures of some of the flowers	Thank you! I want to visit the real Bergen Swamp now!
9	Call a guide (kidding), but access to additional information though	Keep on the efforts - fantastic
10	Prizes/games	Get colleges/high schools involved
11	Food!	no
12		no
13		Thank you
14	don't know	The swamp sounds like a place I want to check out.
15		Make a reality show / comic version / with "Mike" the caregiver to swamp - could become a fund raiser for the swamp. This will bring in families.
16	Make it narrated and user friendly	
17	very good presentation / looking forward to the final product	
18	Be able to ask questions or search	No Donuts, etc.
19	Tailor the exhibit for who is in the tour. One for those who are more interested in birds, one for plants, one for school kids. Some that are less technical.	This is all a great idea! Can't wait until we see what you come up with next.
20	more information on Birds/Plants on web site	
21	Adding natural sounds and also how it would look in different seasons	Loved the visitation and looking forward to visit the Bergen Swamp in person.

22	Be able to retain information on the device	Received more information from AR but AR and guide would be great.
23	Add Trex and all the other interesting things	I enjoyed this experience as much as a Trex enjoys mastodon meat
24	For education k-12 you need a game like scavenger hunt - something more interactive that will engage them more. Kids aren't big on just reading text and looking at photos.	I enjoyed the virtual reality experience Sometime your screen is not visible in outdoor sunlight, also adapts for visually impaired.
25	What you currently have is wonderful. The addition of augmented reality is a great step forward. Having some type of interactive Q&A app would be of great value.	
26	Make it as easy to use as possible	
27	Use AR to supplement the tour and provide a much greater learning experience.	I really enjoyed this glimpse of how newer technologies can be used to further improve an educational experience

Table 1: Results of open-ended questions

Many of these responses are duplicates of what was covered in the debriefing session. Some of the suggestions, like include wine, were not covered in the debriefing session. By the end of the study the participants had formed a comradery and were comfortable joking with each other. While filling out these questions they continued to talk to each other about the exhibit. The response from #15 occurred when the one of the groups started brainstorming ideas. It started with one of the participants asking the trail guide about the people who manage the property. The trail guide docent shared with the group that the Bergen Swamp has a dedicated caretaker who lives on the property. His name is Mike and he is called “Swamp Man Mike” by people in the town of Bergen. This was the starting point for making a reality show of Swamp Man Mike for a fund raiser. Or create a cartoon character called “Swamp Man Mike” who takes kids on tours of the swamp. Each tour could focus on something new to learn. This end of the study discussion that occurred while people were finishing the ranking survey and leaving resulted in some creative ideas.

DISCUSION

The results of the interest and enjoyment and learnability were the opposite of what was anticipated. About 80% of the participants did not like the knowledge survey. Some of the older participants even refused to continue on with the experiment until they were given the answers. Interestingly all participants who were currently in college did not make negative comments on the knowledge survey. It was only the older adults who have been out of school for many years who were the most vocal about it. The participants were good sports about the knowledge survey but were not shy in expressing their opinions of it, primarily that it was too hard. Based on these comments it was anticipated that the results would show no significant difference. However, the results showed the opposite, a significant difference between the AR method and the non-AR method.

The debriefing provided more insight into this. Participants felt they learned more from the AR content than the trail guide docent. They pointed out the different learning styles they have. Some felt they learned more with the AR because they could review the material at their own pace. Some stated they retained more information when they read it than when they heard it. Others felt having a picture to associate content with was very helpful for remembering the content. More importantly, having the AR content to review and being able to ask the trail guide docent questions was a common theme as to why the AR method improved learnability.

In contrast, it was anticipated that the interest and enjoyment part of the study would show a significant difference based on the participant's positive reaction during the experiment and debriefing. But the results showed no significant difference in interest and enjoyment between

the AR method and non-AR method. This may be because the experiment used only two methods and needed to test three methods; non-AR method, AR method, and both.

Overall this experiment has shown that using AR to provide supplemental information in a living museum in conjunction with a trail guide docent is a viable option to explore further. Participants overwhelmingly wanted to experience the exhibits with both methods. When participants were using the AR method and allowed to ask the trail guide docent questions, they inadvertently experienced both methods. This discovery, while not intended, did provide valuable information.

The interaction with the trail guide docent was as much a part of the experience as the content covered. The story telling method of presenting the exhibit information engaged the participants. This interaction tended to turn into a discussion with the trail guide docent and other participants in the group. Comradery developed in the group was not factored into the experiment.

It is not known if AR is the driver for a significant difference in learnability or if AR with verbal interaction with the trail guide docent is the driver for the significant difference in learnability. To determine this, the experiment would need to be repeated with three conditions.

1. Trail guide docent only
2. AR only
3. Trail guide docent and AR

The interest measurement was not considered a robust method of measurement by participants. They did not like the revered wording, with some questions positively-keyed and other questions negatively-keyed. It was assumed that using an established tool to measure enjoyment would be reliable, but the revered wording did confuse the participants. It is also not known how many participants did not catch the revered wording or if this factored into the interest and enjoyment results. Additional work is needed to find a robust method for measuring interest and enjoyment in order to be confident with the results.

FUTURE WORK

The short term work will be to repeat the experiment on the Pocock trail, get 3D images of some of the smaller plants and animals, add links to the slide show, add video of the trail from one exhibit to the next and add bird calls or links to bird calls. While these enhancements scored lower on the ranking scale, they will be added first because either the content exists or it will exist in the next 3-4 months.

The experiment is scheduled to be repeated in the Bergen Swamp on May 9, 2017 weather permitting, with a rain date of May 23, 2017. The objective is to learn if the results will be the same and how viable the procedure is when executed on the real Pocock trail. The procedure, instruments, etc. will be the same as this experiment.

In the summer semester of 2017, and in cooperation with The Construct at RIT, work will begin to get three dimensional images of some of the smaller but popular living things, such as the eastern massasauga rattlesnake, the bog turtle and the lady slipper orchid. The objective is to add 3D imaging to the AR supplemental information to break up the current static imaging.

In the fall of 2016 video was taken of the walk from exhibit to exhibit and the speed will be increased to quickly show the visitor what is up ahead. These videos will be added to the supplemental material along with links for additional information and links to the bird calls.

The 360^{o} AR of each exhibit stop will begin in the summer semester when the imagery will be captured for all 10 exhibits. This will be repeated in the fall and winter of 2017 and the spring of

2018. In a year's time the 360º imagery of each exhibit stop on the Pocock trail will be incorporated into the exhibit. The 360º imagery of Lake Tonawanda and the glaciers will require more planning. The challenge will be finding a place on earth with the geology and landscape similar to Lake Tonawanda and the Glaciers that were in the swamp.

The GEO AR simulation of the Mastodon and Bald Eagle will require the most time to complete because of the cost. Preliminary estimates for getting a 60 second 3D, life like and animated mastodon was $7,000 to $10,000. The animation was simply having the Mastodon turn its head. Cost will go up to have the Mastodon grazing while a baby mastodon plays in the grass. Planning will be needed to determine how this can be paid for, and if a grant or donation can be secured.

CONCLUSION

This purpose of this research was to understand if using mobile AR to view the supplemental information of a living museum exhibit affects the visitor experience. Visitor experience was measured by enjoyment and learning. It was discovered that using mobile AR to view supplemental information in a living museum does affect the visitor experience. Quantitatively it improves the learnability of exhibit material but does not improve visitor enjoyment. Qualitative results show that it does improve the visitor enjoyment when both the AR and non-AR methods are used together.

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Appendix A: Recruiting Flyer

Appendix B: Recruiting Emails

SUBJECT LINE: Would you like to participate in a research study?

Hello,

My name is Rita Locke Pettine, and I am doing a study for my Capstone thesis at RIT and for the Bergen Swamp Preservation Society. In an effort to improve the living museum exhibit experience I am looking for people who are interested in walking through an exhibit that uses a AR method of providing supplemental information and provide me with feedback about their experience.

The Bergen Swamp is the first private environmental land trust in the United States chartered as a New York State living museum. It is also the property of the Bergen Swamp Preservation Society, whose purpose is to protect upstate New York habitats.

Participants must be 18 years of age or older.

What will I be doing in this study?

You will be asked to evaluate 5 current exhibits and 5 exhibits using the AR method. You will also be asked questions about your experience.

How long is a session? 1 to 1-1/2 hours.

When and where?

The study will be held at:
Ellucian
3000 Ridge Road East,
Rochester New York 14622

Link to the study location:
https://www.google.com/maps/place/3000+East+Ridge+Road,+Rochester,+NY+14622/@43.205196,-77.543513,17z/data=!3m1!4b1!4m5!3m4!1s0x89d6c9c02fce7631:0x3788c3cc5c697ff8!8m2!3d43.205196!4d-77.541319

Interested in participating?

Please reply to this email with your contact information or call me at 585-509-0102. I will give you a call and ask you some questions to help me determine if you qualify for the study.

If you have any questions, please contact me at rxl3783@rit.edu

Thank you for interest,
Rita Locke Pettine

Confirmation Email

SUBJECT LINE: Confirmation of your participation in my study

Dear [PARTICIPANT NAME]:

Thank you for agreeing to participate in the study that uses a AR method of providing supplemental information about exhibits and its impact on the visitor experience in a living museum.

Please choose a date and time you can participate and an alternate date on this Doodle Poll:

http://doodle.com/poll/a8ftwdxxa9k6yny8

A few key reminders:

- A follow up email will be sent to you with details confirming your scheduled date, time and directions to the study.
- Please review and sign the attached informed consent form and bring it with you to the study. This form will need to be signed before you can participate in the study. I will have extra forms available for you in case you forget to bring this one.
- During the study, I will ask you to walk approximately ¼ of a mile outside. Please dress appropriately. If the weather is severe the exhibit will be brought inside.
- With your permission, the session will be video and audio recorded. I will only use the recording to decide how to improve the experience. Your name will not be used for any purpose beyond this session. If you choose to not to be recorded on video or audio, I will make arrangements to accommodate you.
- Participants must be 18 years of age or older.

Thank you again!

Rita Locke Pettine

585-509-0102

rxl3783@rit.edu

Reminder Email

SUBJECT LINE: Reminder: Study of new method of providing supplemental information tomorrow

Dear [PARTICIPANT NAME]:

Thank you again for agreeing to help me with my study of a new method of providing supplemental information about exhibits and its impact on the visitor experience in a living museum. I am looking forward to talking with you.

You are scheduled to participate as follows:
DATE: [DAY, DATE]
TIME: [TIME]
PLACE: [ADDRESS, LINK TO MAP]

Alternate Date in case I need to reschedule.
DATE: [DAY, DATE]
TIME: [TIME]

Link to the study location:
https://www.google.com/maps/place/3000+East+Ridge+Road,+Rochester,+NY+14622/@43.205196,-77.543513,17z/data=!3m1!4b1!4m5!3m4!1s0x89d6c9c02fce7631:0x3788c3cc5c697ff8!8m2!3d43.205196!4d-77.541319

A few key reminders:

- During the study, I will ask you to walk approximately ¼ of a mile outside. Please dress appropriately. If the weather is severe the exhibit will be brought inside.
- With your permission, the session will be video and audio recorded. I will only use the recording to decide how to improve the experience. Your name will not be used for any purpose beyond this session. If you choose to not to be recorded on video or audio, I will make arrangements to accommodate you.
- Participants must be 18 years of age or older.

Also, if you find that you cannot participate on your scheduled day, please contact me as soon as possible so I can reschedule your session.

Thanks again!

Rita Locke Pettine
rxl3783@rit.edu

Rejection Email

SUBJECT LINE: Thank you for your interest in participating in my study

Dear [PARTICIPANT NAME]:

Thank you for your interest in participating in my study of a new method of providing supplemental information about exhibits and its impact on the visitor experience in a living museum. I received many applications, only some of which I was able to accept. I reviewed your application very carefully and yours was not among those that I was able to accept.

I appreciate your interest in my study and I wish you all the best.

Sincerely,

Rita Locke Pettine

rxl3783@rit.edu

Appendix C: Recruitment Screening

By Online Survey

Qualtrics on line survey

https://survey.qualtrics.com/SE/?SID=SV_6x7ORnR8pMfXiol

http://tinyurl.com/ztvlf63

Participant Recruitment Online Screening Survey

Hello,

My name is Rita Locke Pettine, and I am doing a study for my Capstone thesis at RIT and for the Bergen Swamp Preservation Society. In an effort to improve the living museum exhibit experience I am looking for people who are interested in walking through exhibits that use a new method of providing supplemental information and provide me with feedback about their experience.

The Bergen Swamp is the first private environmental land trust in the United States chartered as a New York State living museum. It is also the property of the Bergen Swamp Preservation Society, whose purpose is to protect upstate New York habitats.

Participants must be 18 years of age or older.

1. Are you 18 years of age or older? (required)

- ❍ Yes
- ❍ No

2. What is your name? (required)

3. What is your email address? (required)

Email Address (xxxx@zzz.com)

4. What is the best telephone number to reach you at?

Telephone Number (XXX-XXX-XXXX)

5. Please leave any additional contact information that you would like us to know in the space provided below.

6. Are you physically able to walk 1/4 mile outside? (required)

- ❍ Yes
- ❍ No

7. Please rate your hiking experience. (required)

- ❍ No experience
- ❍ Beginner level - such as hiking in local parks on trails that are maintained
- ❍ Intermediate level - such as hiking in local parks off trail
- ❍ Experienced - such as remote wilderness

8. Have you ever walked the Pocock trail in the Bergen Swap?

- ❍ Yes
- ❍ No
- ❍ Not sure

9. Do you have transportation to Ellucian? (required)

Location:

3000 Ridge Road East

Rochester, New York 14622

- ❍ Yes
- ❍ No
- ❍ Not sure

10. Do you know how to use the camera on a smartphone or tablet? (required)

- ❍ Yes
- ❍ No
- ❍ Not sure

11. Do you own a smartphone or tablet? (required)

- ❍ Yes
- ❍ No

If you have any questions, please contact me, Rita Locke Pettine, at rxl3783@rit.eduThank you for your interest in participating in this study.

Rita Locke Pettine

By Phone

Introduction

My name is Rita Locke Pettine, and I am doing a study for my Capstone thesis at RIT and for the Bergen Swamp Preservation Society. In an effort to improve the living museum exhibit experience I am looking for people who are interested in walking through an exhibit that uses a new method of providing supplemental information and provide me with feedback about their experience. Participants must be 18 years of age or older.

The study will determine if using a new method of providing information material for an exhibits' interpreted materiel improves the visitor experience. I am doing this for my Capstone Thesis and for the Bergen Swamp Preservation Society. The Bergen Swamp is the first private environmental land trust in the United States chartered as a New York State living museum. It is also the property of the Bergen Swamp Preservation Society, whose purpose is to protect upstate New York habitats.

The study will take place at Ellucian, located in Irondequoit at 3000 Ridge Road East.

Does this sound like something that interests you? Before I schedule you for a session, do you have a few moments to answer some questions?

General Questions

Are you 18 or older? [if no, terminate]

Are you physically able to walk 1/4 mile outside? [If no, terminate]

Do you have transportation to Ellucian in Irondequoit? [if no terminate]

Do you know how to use the camera on a smartphone or tablet? [if no terminate]

Handheld Device Expertise

Are you comfortable using the camera on a smartphone or table? [if no ask what the issue is. If the issue is not a physical limitation ask if they would be willing to learn. Evaluate the answer to determine if this should terminate.]

Do you have a smartphone or tablet? [If no they can barrow one for the study]

Hiking Expertise

Have you ever walked the Pocock trail in the Bergen Swamp?

Please rate your hiking experience.

No experience [Why do they feel they can walk 1/4 mile outside on a rugged trail if they have no hiking experience? Terminate if they cannot walk]

Beginner level - such as hiking in local parks on trails that are maintained

Intermediate level - such as hiking in local parks off trail

Experienced – such as remote wildernesses

Contact Information

[If the person matches my qualifications, ask] May I have your contact information?

Name of participant: _____

Phone number: _____

Email address: _____

Those are all the questions I have for you. Your background matches the people we're looking for. Would you be able to participate in February or March of 2017?

Before your session starts, I will ask you to sign a release form allowing us to videotape your session. The videotape will only be used internally for further study if needed. Will you consent to be videotaped?

This study will take place at Ellucian. I will confirm your appointment a couple of days before your session and provide you with directions. What is the best way to reach you?

Thank you

Appendix D: IRB Approval

R·I·T

Rochester Institute of Technology

RIT Institutional Review Board for the
Protection of Human Subjects in Research
141 Lomb Memorial Drive
Rochester, New York 14623-5604
Phone: 585-475-7673
Fax: 585-475-7990
Email: hmfsrs@rit.edu

Form C
IRB Decision Form

TO: Rita Locke

FROM: RIT Institutional Review Board

DATE: **January 25, 2017**

RE: Decision of the RIT Institutional Review Board

Project Title – Evolution of the Museum Experience: Mobile Augmented Reality's Impact on the Visitor Experience at an Outdoor Living Museum

The Institutional Review Board (IRB) has taken the following action on your project named above.

☒ Exempt 46.101 (b) (2)

Now that your project is approved, you may proceed as you described in the Form A.

You are required to submit to the IRB any:

- **Proposed** modifications and wait for approval before implementing them,
- Unanticipated risks, and
- Actual injury to human subjects.

Heather Foti, MPH
Associate Director
Office of Human Subjects Research

Revised 10-18-06

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

COMPLETION REPORT - PART 1 OF 2
COURSEWORK REQUIREMENTS*

* NOTE: Scores on this Requirements Report reflect quiz completions at the time all requirements for the course were met. See list below for details. See separate Transcript Report for more recent quiz scores, including those on optional (supplemental) course elements.

- **Name:** Rita Locke (ID: 5778917)
- **Email:** rxl3783@rit.edu
- **Institution Affiliation:** Rochester Institute of Technology (ID: 1728)
- **Institution Unit:** Information Sciences & Technologies
- **Phone:** 585 964 9949

- **Curriculum Group:** Social & Behavioral Research - Basic/Refresher
- **Course Learner Group:** Same as Curriculum Group
- **Stage:** Stage 1 - Basic Course
- **Description:** Choose this group to satisfy CITI training requirements for investigators and staff involved primarily in Social/Behavioral Research with human subjects.

- **Report ID:** 20741443
- **Completion Date:** 23-Oct-2016
- **Expiration Date:** 23-Oct-2019
- **Minimum Passing:** 80
- **Reported Score*:** 98

REQUIRED AND ELECTIVE MODULES ONLY	DATE COMPLETED	SCORE
Rochester Institute of Technology (ID: 13854)	11-Oct-2016	No Quiz
Populations in Research Requiring Additional Considerations and/or Protections (ID: 16680)	11-Oct-2016	5/5 (100%)
Belmont Report and CITI Course Introduction (ID: 1127)	11-Oct-2016	3/3 (100%)
History and Ethical Principles - SBE (ID: 490)	11-Oct-2016	5/5 (100%)
Defining Research with Human Subjects - SBE (ID: 491)	11-Oct-2016	5/5 (100%)
The Federal Regulations - SBE (ID: 502)	11-Oct-2016	5/5 (100%)
Assessing Risk - SBE (ID: 503)	11-Oct-2016	5/5 (100%)
Informed Consent - SBE (ID: 504)	11-Oct-2016	5/5 (100%)
Privacy and Confidentiality - SBE (ID: 505)	11-Oct-2016	5/5 (100%)
Conflicts of Interest in Research Involving Human Subjects (ID: 488)	16-Oct-2016	5/5 (100%)
Unanticipated Problems and Reporting Requirements in Social and Behavioral Research (ID: 14928)	14-Oct-2016	5/5 (100%)
Students in Research (ID: 1321)	23-Oct-2016	5/5 (100%)
Research in Public Elementary and Secondary Schools - SBE (ID: 508)	23-Oct-2016	4/5 (80%)

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

Verify at: https://www.citiprogram.org/verify/?4f5a90c2-f56b-4738-bdf2d-0136d1b6c995

CITI Program
Email: support@citiprogram.org
Phone: 888-529-5929
Web: https://www.citiprogram.org

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI PROGRAM)

COMPLETION REPORT - PART 2 OF 2
COURSEWORK TRANSCRIPT**

** NOTE: Scores on this Transcript Report reflect the most current quiz completions, including quizzes on optional (supplemental) elements of the course. See list below for details. See separate Requirements Report for the reported scores at the time all requirements for the course were met.

- **Name:** Rita Locke (ID: 5778917)
- **Email:** rxl3783@rit.edu
- **Institution Affiliation:** Rochester Institute of Technology (ID: 1728)
- **Institution Unit:** Information Sciences & Technologies
- **Phone:** 585 964 9949

- **Curriculum Group:** Social & Behavioral Research - Basic/Refresher
- **Course Learner Group:** Same as Curriculum Group
- **Stage:** Stage 1 - Basic Course
- **Description:** Choose this group to satisfy CITI training requirements for investigators and staff involved primarily in Social/Behavioral Research with human subjects.

- **Report ID:** 20741443
- **Report Date:** 12-Nov-2016
- **Current Score**:** 98

REQUIRED, ELECTIVE, AND SUPPLEMENTAL MODULES	MOST RECENT	SCORE
Students in Research (ID: 1321)	23-Oct-2016	5/5 (100%)
Rochester Institute of Technology (ID: 13854)	11-Oct-2016	No Quiz
History and Ethical Principles - SBE (ID: 490)	11-Oct-2016	5/5 (100%)
Defining Research with Human Subjects - SBE (ID: 491)	11-Oct-2016	5/5 (100%)
Belmont Report and CITI Course Introduction (ID: 1127)	11-Oct-2016	3/3 (100%)
The Federal Regulations - SBE (ID: 502)	11-Oct-2016	5/5 (100%)
Assessing Risk - SBE (ID: 503)	11-Oct-2016	5/5 (100%)
Informed Consent - SBE (ID: 504)	11-Oct-2016	5/5 (100%)
Privacy and Confidentiality - SBE (ID: 505)	11-Oct-2016	5/5 (100%)
Research with Children - SBE (ID: 507)	16-Oct-2016	Quiz Not Taken
Research in Public Elementary and Secondary Schools - SBE (ID: 508)	23-Oct-2016	4/5 (80%)
Unanticipated Problems and Reporting Requirements in Social and Behavioral Research (ID: 14928)	14-Oct-2016	5/5 (100%)
Conflicts of Interest in Research Involving Human Subjects (ID: 488)	16-Oct-2016	5/5 (100%)
Populations in Research Requiring Additional Considerations and/or Protections (ID: 16680)	11-Oct-2016	5/5 (100%)
Consent Tools Used by Researchers (ID: 16944)	16-Oct-2016	Quiz Not Taken

For this Report to be valid, the learner identified above must have had a valid affiliation with the CITI Program subscribing institution identified above or have been a paid Independent Learner.

Verify at: https://www.citiprogram.org/verify/?4f6a90c2-f56b-4738-bd2d-0136d1b6c995

Collaborative Institutional Training Initiative (CITI Program)
Email: support@citiprogram.org
Phone: 888-529-5929
Web: https://www.citiprogram.org

Appendix E: Informed Consent Form

Research: Study of a new method of providing supplemental information and its impact on the visitor experience at an outdoor Living Museum
Study: The impact of enjoyment and learnability on the visitor experience

INTRODUCTION
You are invited to participate in a research study that will determine a new method of providing supplemental information's impact on the visitor experience in the Bergen Swamp's Living Museum. Please take whatever time you need to discuss the study with your family and friends, or anyone else you wish to. The decision to join, or not to join, is up to you.

In this research study, I am investigating a new method of providing supplemental information's impact on the visitor experience in a Living Museum. Participants in this study will be asked to evaluate 10 exhibits used on the Pocock Trail located in the Bergen Swamp, without the new method and with the new method. The Pocock Trail is not accessible in February and March so the study will take place at Ellucian, 3000 Ridge Road East, Rochester, New York 14622. The exhibit will be located outside on the Ellucian property to simulate the experience of an outside exhibit. If the weather is severe the exhibit will be brought inside.

The Bergen Swamp is a protected 2,000-acre 400 million year old swamp and nature preserve located in the towns of Byron and Bergen, New York. The BSPS (Bergen Swamp Preservation Society) was formed in 1935 to protect and preserve this delicate ecological environment. In 1964 it was designated a Natural Landmark and Living Museum. The Bergen Swamp is the Living Museum where this study will take place. The 10 exhibits that will be studied are located on the Pocock Trail.

The study will help the Bergen Swamp Preservation Society determine if the new method of providing supplemental information does improve the visitor enjoyment of the exhibit.

WHAT IS INVOLVED IN THE STUDY?
If you decide to participate you will be asked to walk about ½ mile outside. The study will begin with an information session about the study and finish with a debriefing. I think this will take you about 1 – 1-1/2 hours.

The study will have two parts,
1. Experience the exhibits following today's method, the guide will verbally provide interpreted material.
2. Experience the exhibits using the new method to provide interpreted material.

For part 1:
Participant will walk the recreated exhibit with a Bergen Swamp certified Trail guide docent and stop at 5 of the 10 exhibits. The guide will verbally present the informative material to the participants explaining the living things at each exhibit. At the end participants will take a short survey to measure their experience of the exhibit.

For Part 2:
Part 2 of this study participants will experience the other 5 exhibits using the new method to provide the interpreted material. At the end participants will take a short survey to measure their experience of the exhibit.

Participants will be with a Certified Trail guide docent at all times to recreate the museum experience as close to the real thing as possible.

The investigators may stop the study or take you out of the study at any time they judge it is in your best interest. They may also remove you from the study for various other reasons and can do this without your consent

You can stop participating at any time.

RISKS
None
1. There may be other risks that we cannot predict.

BENEFITS TO TAKING PART IN THE STUDY?
It is reasonable to expect the following benefits from this research:
1. Learning about rare and endanger plants and animal in your region.
2. Experiencing a 400 million year old Living Museum.
3. Experiencing a habitat that has been untouched by man.
However, I can't guarantee that you will personally experience benefits from participating in this study. Others may benefit in the future from the information I find in this study

CONFIDENTIALITY
I will take the following steps to keep information about you confidential, and to protect it from unauthorized disclosure, tampering, or damage:

Participant names will be used on paper forms like this one that require a signature or identify participant contact information. These forms will be kept in a secure location to be accessed only by myself Rita Locke Pettine and the study's primary investigators. The Primary investigators are:

Rita Locke Pettine – RIT student Researcher of this study
Vicki Hanson RIT Distinguished professor and capstone committee chair
Bryan French, RIT Lecturer and capstone committee member
Deb LaBelle, RIT Lecturer and capstone committee member
Trustees of the Bergen Swamp Preservation Society

Participants will also identify themselves on survey instruments and verbal communication between participants and the studies facilitators. To protect participant confidentiality and anonymity each participant will be assigned a unique user id. This id will be used to associate a participant with a quote, a comment to the investigators or a recording.

INCENTIVES
None

YOUR RIGHTS AS A RESEARCH PARTICIPANT?
Participation in this study is voluntary. You have the right not to participate at all or to leave the study at any time. You have the right to skip questions in the survey if you choose not to answer. Deciding not to participate or choosing to leave the study or choosing to skip survey questions will not result in any penalty or loss of benefits to which you are entitled, and it will not harm your relationship with Rita Locke Pettine, Rochester Institute of Technology or the Bergen Swamp Preservation Society.

To withdraw from the study please notify Rita Locke Pettine by email at rxl3783@rit.edu

CONTACTS FOR QUESTIONS OR PROBLEMS?
Call Rita Locke Pettine at 585-509-0102 or email at her at rxl3783@rit.edu or email

Distinguished Professor Vicki Hanson at vlhics@rit.edu if you have questions about the study, any problems, unexpected physical or psychological discomforts, any injuries, or think that something unusual or unexpected is happening.

Contact Heather Foti, Associate Director of the HSRO (Human Subjects Research Office) at (585) 475-7673 or hmfsrs@rit.edu (link sends e-mail) if you have any questions or concerns about your rights as a research participant.

Consent of Subject (or Legally Authorized Representative)

_____

Signature of Participant or Representative Date

Appendix F: Pre-study Script

Thank you all for coming today. Does everyone have a name tag sticker?

[if no give them a sticker]

Let me fill you in on what you will be doing today and also take any questions you might have before we get started.

Today you will be participating in a study of the impact Augmented Reality has on the visitor experience in a Living Museum. I am doing this study for my Capstone Thesis and for the Bergen Swamp Preservation Society. The BSPS has an exhibit in the Bergen Swamp on the Pocock trail that I have replicated here at Ellucian. The Pocock trail is not accessible in February and March so we re-created it here for this study.

The Bergen Swamp is a protected 2,000-acre 400 million year old swamp and nature preserve located in the towns of Byron and Bergen, New York. The BSPS (Bergen Swamp Preservation Society) was formed in 1935 to protect and preserve this delicate ecological environment. In 1964 it was designated a Natural Landmark and Living Museum.

My goal is to learn what impact augmented reality has on the visitor experience in a Living Museum. Since you are not actually in the swamp you will not see many of the living things. But since it is winter, even if you were in the swamp, many of the living things would not be visible. Please do you your best to relax and pretend you are walking down the Pocock trail.

There are two parts to this study, part 1 is to learn about your experience at 5 of the 10 exhibits as it is presented to visitors today. Part 2 is to learn about your experience at the other 5 exhibits in a new way that uses augmented reality.

You will be led by our certified trail guide docent [FILL IN NAME] who will be with you at all times. This is required by the Bergen Swamp Preservation Society for all groups of visitors to ensure their safety. Even though we are not in the Bergen Swamp I am using the same procedure because I want to recreate the experience as best I can. And since BSPS requires a guide for all groups my study will also have a guide.

He/she is here to ensure your safety and to lead you through the exhibits the way we do it today.

Participant's Role

Today all of you will be participants in this study. Your role is to walk through the re-created Pocock trail exhibit and provide us with information regarding your experience. Please enjoy the walk, the fresh air and beauty as you would if you were in the swamp for a casual hike. Along the way you will stop at 5 exhibits.

After the 5th exhibit you will have a brief debriefing with the trail guide docent and complete a survey of your experience.

On your way back you will stop at the other 5 exhibits and use a mobile device to review the information material associated with each exhibit and presented using augmented reality. Your trail guide docent will still be with your group but is there only to answer questions.

When you are done you will have a brief debriefing with the trail guide docent and complete a survey of your experience.

Do you have any questions?

Participant training

Demo the app and have all participants do a practice round.

Do you have any questions before we begin?

I will now turn this over to [NAME OF TRAIL GUIDE] to explain the rules and procedures for visitors in the swamp.

Appendix G: Interest and Enjoyment survey

Which method providing supplemental information was used?

- ❍ Non-AR method (A guided tour)
- ❍ AR method

Choose exhibits

- ❍ ☐ Exhibits 1 through 5
- ❍ ☐ Exhibits 6 through 10

For each of the following 7 statements, please indicate how true the statement is for you using the following scale.

1 - Not at all true
2
3
4 - Sometimes true
5
6
7 - Very True
Please make a selection for all 7 of the following statements.

1. I enjoyed doing this activity very much.

- ❍ 1 - Not at all true
- ❍ 2
- ❍ 3
- ❍ 4- Somewhat true
- ❍ 5
- ❍ 6
- ❍ 7- Very true

2. This activity was fun to do.

- ❍ 1 - Not at all true
- ❍ 2
- ❍ 3
- ❍ 4- Somewhat true
- ❍ 5
- ❍ 6
- ❍ 7- Very true

3. I thought this was a boring activity.

- ❍ 1 - Not at all true
- ❍ 2
- ❍ 3
- ❍ 4- Somewhat true
- ❍ 5
- ❍ 6
- ❍ 7- Very true

4. This activity did not hold my attention at all.

- ❍ 1 - Not at all true
- ❍ 2
- ❍ 3
- ❍ 4- Somewhat true
- ❍ 5
- ❍ 6
- ❍ 7- Very true

5. I would describe this activity as very interesting.

- ❍ 1 - Not at all true
- ❍ 2
- ❍ 3
- ❍ 4- Somewhat true
- ❍ 5
- ❍ 6
- ❍ 7- Very true

6. I thought this activity was quite enjoyable.

- ❍ 1 - Not at all true
- ❍ 2
- ❍ 3
- ❍ 4- Somewhat true
- ❍ 5
- ❍ 6
- ❍ 7- Very true

7. While I was doing this activity, I was thinking about how much I enjoyed it.

- ❍ 1 - Not at all true
- ❍ 2
- ❍ 3
- ❍ 4- Somewhat true
- ❍ 5
- ❍ 6
- ❍ 7- Very true

Appendix H: Knowledge survey

Exhibits 1-5

Which method providing supplemental information was used?

- ❍ Non-AR method (A guided tour)
- ❍ AR method

Choose exhibits

- ❍ Exhibits 1 through 5
- ❍ Exhibits 6 through 10

1. What lake was in the Bergen Swamp 10,000 years ago?

- ❍ Lake Bergen
- ❍ Lake Erie
- ❍ Lake Ontario
- ❍ Lake Tonawanda

2. What is a swamp?

- ❍ A wetland with trees as the predominant plant
- ❍ A wetland with grasses as the predominant plant
- ❍ A wetland with reeds as the predominant plant
- ❍ A wetland with cattails as the predominant plant

3. What forest existed here 70 years ago?

- ❍ Redwood
- ❍ American Elm
- ❍ American Beech
- ❍ American Walnut

4. What is the habitat for the small northern yellow lady's slipper & the showy lady’s slipper?

- ❍ Pelagic realm
- ❍ Benthic realm
- ❍ Aphotic zone
- ❍ Biome zone

5. The trees & plants of the swamp floor form a _____

- ❍ Acidic peat mat
- ❍ Arid reed mat
- ❍ Basic peat mat
- ❍ Basic reed mat

Exhibits 6-10

Which method providing supplemental information was used?

- ❍ Non-AR method (A guided tour)
- ❍ AR method

Choose exhibits

- ❍ Exhibits 1 through 5
- ❍ Exhibits 6 through 10

6. Which researcher from SUNY Potsdam completed a survey of the Bergen Swamp in 1994 and was the first to identify the Queen snake?

- ❍ Dr. Gerry Johansson
- ❍ Dr. Glenn Johnson
- ❍ Dr. Gabriel Johansson
- ❍ Dr. Gavin Johnson

7. These plants are in a Mycorrhizae relationship with the soil _____?

- ❍ Mycorrizal fungi
- ❍ Harpellales fungi
- ❍ Tempeh fungi
- ❍ Actinomucor elegans fungi (4)

8. Which 2010 graduate of Byron-Bergen HS performed a Census & Survey of the Spotted Turtle?

- ❍ Nathen Hollenbeck
- ❍ Nicholas Haywood
- ❍ Neil Howard
- ❍ Nolan Hammersmith

9. Most of the early botanists that identified our curator list of plants were members of what society?

- ❍ Rochester Greenovation
- ❍ Rochester Academy of Science
- ❍ Genesee Country Nature Center
- ❍ Rochester Regional Group Sierra Club

10. The plants at exhibit 6 are tolerant to both _____

- ❍ dry soil and full shade
- ❍ dry soil and full sun
- ❍ wet soil and full sun
- ❍ wet soil and full shade

Appendix I: Ranking the Enhancements Survey

1. The following are a list of enhancements we can make to the Pocock Trail exhibits. Please rank them in the order you would like to see them completed.

_____ Include natural sounds at each exhibit
_____ Add narration or the option for narriation of the slides
_____ Use GEO Augmented Reality
_____ Use 360 degree Augmented Reality
_____ Add three dimensional objects
_____ Show video of the path from one exhibit to the next
_____ Show a docent in 3D narrating an introduction to the exhibit
_____ Include a Link to web pages with more information.
ie Add the link http://www.audubon.org/bird-guide for additional information on a specific bird.

2. What additional features would you like to have?

3. Would having this exhibit made into a Virtual Reality experience be something you would watch?

- ❍ Yes
- ❍ Maybe
- ❍ No
- ❍ Don't know

4. Would you purchase the Virtual Reality experience of this exhibit?

- ❍ Yes
- ❍ Maybe
- ❍ No

5. What can we do to make this a fantastic experience?

6. Is there anything else you would like to tell us?

Thank you for participating in this study. Rita Locke Pettine and the Bergen Swamp Preservation Society are very grateful for your support. Have a fabulous day!