EXPLORING HOW ONE VIRTUAL HERITAGE APPLICATION CONNECTS USERS TO HISTORICAL CONTENT:
A USER EXPERIENCE CASE STUDY

A THESIS
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1. Introduction

VH is often defined as the creation of historically significant objects and environments with the use of 3D computer modeling and virtual reality. Virtual heritage became a significant field of study and practice at the beginning of the 21st Century. It grew from the field of archaeology and was facilitated by the growth of 3D modeling programs such as Computer Aided Design (CAD) software. These programs were well suited for use by archaeologists who started using them to render and reconstruct buildings and sites to study their finds from new perspectives.

During the past 10 to 15 years, virtual heritage has been concerned with projects that try new approaches to recreating history in the virtual world. In many cases, these efforts have resulted in static environments or spaces that users can explore as an illustration of how something used to look. For example, one such project is *Rome Reborn*, a virtual reconstruction of ancient Rome (around 320 C.E.) that provides a chance to see what the city looked like at its peak (Guidi, Frischer & Lucenti, 2007). Currently, this project can only be viewed through a gallery of images or a video tour that is a flythrough of the virtual environment – an illustrative experience but ultimately not very informative to those who know little about ancient Rome. As the technology and practice evolves, practitioners are now exploring how these computer-rendered environments might be used as tools to connect users to historical content and actively inform them about the past. Many things can be explained to a user about a space or object in order to give it context and enhance its meaning. For example, how was the building, site, or object made? What kind of people used it? How did they use it? How did it relate to the culture of the era?
The Virtual Buffalo Bill’s Wild West (VBB) project is a virtual heritage application that integrates historical information into a virtual environment. This is an initiative sponsored by the Buffalo Bill Center of the West in Cody, Wyoming and is being created by research and development teams at Ball State University in Muncie, Indiana. The Buffalo Bill Center commissioned this project in an attempt to discover a new way to illustrate a historic and cultural event through an immersive 3D environment. Additionally, the Center hopes to provide a novel approach to connecting users and visitors to museum resources, such as their digitized archival collections.

Currently, the VBB project exists as a prototype for a computer-rendered model of the Buffalo Bill’s Wild West exhibition as it would have looked in 1899. This virtual world is combined with a digital archive that catalogs objects, documents, and pictures of people and places. These materials (often termed *paradata*) were used as references during the virtual recreation process. Users access the archive through a head-up display (HUD) that is integrated into the virtual environment. This archival integration has two goals: 1) to get the user to explore the paradata materials used to inform the construction of the 3D models and 2) to get users interested in learning more about the history of both the show and the people involved in the show.

To date, the VBB creators have not conducted any formal usability and/or user experience research to thoroughly examine whether their project meets its key aims. Thus, this thesis will address two key research questions: 1) To what extent do VBB users explore the paradata materials used to inform the construction of the 3D models? 2) How effectively does the VBB experience engage users when it comes to learning more about the history of the Wild West exhibition and people involved in it? Answering these questions is important for two
reasons. First, the work laid out in this thesis will help test the effectiveness of specific novel archival integration features of the *Virtual Buffalo Bill’s Wild West* (VBB) project. This brand of usability and user experience work is critical for any complex system that engages users in interactive experiences designed to entertain, inform, or educate. Second, and perhaps even more important, this research will shed light on whether these or similar archival integration features are worthy of consideration for other virtual heritage initiatives. In this regard, the results of this specific research project may have broader implications for future design and development in this field.

![Figure 1.1](image_url)

**Figure 1.1.** Example of the Head-Up Display (HUD) that appears to provide background information to users. The HUD appears in different locations in the recreation and provides pictures and text explaining the significance of each part of the show as well as the duties of the show's cast and crew.
Figure 1.2. Virtual recreation of the Wild West. This is what users see as they enter the recreated environment. They can enter the show tent or choose to wander the backstage area where the cast and crew pitch their tents and learn more about the history of the Wild West.

Figure 1.3. Users can access all in-world informational content from the main menu of the HUD.
Figure 1.4. Users can watch in-word video assets that provide original footage of the Wild West exhibition as well as its cast and crew.

Figure 1.5. The homepage of the web-based archive that provides historical context about the Wild West exhibition’s visit to Muncie, Indiana, as well as a database of images from the show.
VH is still very much a developing field, and questions remain about how best to incorporate all of this historical background information in VH projects. This has resulted in projects that experiment with the use of evolving virtual reality (VR) technologies and inclusion of interactive features, such as game mechanics or digital archives. However, practitioners are still trying to evaluate which design approaches work better than others.

This thesis makes two significant contributions. First, this study provides a comprehensive look at the user experience and usability of a new VH project and its unique features. The field of VH has been growing alongside technological advancement, and many VH projects are experimental, testing different capabilities and features. The Virtual Buffalo Bill project is another one of these experiments. At this point, VBB exists as a prototype with a wide variety of possible in-world interactive features. As such, it provides an opportunity to test different ways to connect VH users with historical source content, with an eye toward finding the best ways to achieve high levels of user engagement. It is the hope that a usability and user experience test of the VBB project will yield a number of suggestions concerning what features resonated well with users as well as those they might want to see added in the future.

Second, this study specifically explores the efficacy of a novel approach to the integration of Internet content in the form of a web-based archive and digital collection. The VBB experience includes a feature that allows users to access additional content about the history of the Wild West or Buffalo Bill by selecting in-world links. This archive is also a way that project developers are trying to comply with the London Charter for the Computer-Based Visualization of Cultural Heritage (2009). The Charter has recommended principles to govern and guide the development of virtual heritage projects, particularly those designed for academic use. According to the Charter, there are certain kinds of information that should be integrated
into a virtual heritage project. For example, one of its principles revolves around the subject of documentation. This principle insists that the developers of VH projects make materials and paradata used in the design process available to users and researchers. On a small level, evaluating the archival integration features will help to reveal how well the VBB project is positioned to comply with the London Charter’s principle of documentation. This process should also help evaluate how effective the project is in encouraging user exploration of historical source materials. And, since the VBB project is envisioned as a smaller part of a larger VH project to be developed in the future, it will help dictate whether specific mechanics are worth replicating in a similar but expanded virtual environment. On a larger scale, this work could determine whether this kind of interactive archive feature is worth implementing in other VH projects. Since there are not many tried and true practices when it comes to VH, determining the usefulness of this feature could help other VH practitioners make good design decisions. And, if it turns out that this feature does not achieve its goals, this research will help practitioners avoid implementing similar ineffective features into their work.
2. Literature Review

Digital humanities can be defined as the use of digital tools to advance the study and practice of the humanities, including the creation of scholarly resources, research on those resources, and the communication of research results and information to colleagues and students (Cohen, 2011). The field of digital humanities is very wide and contains subfields for every individual humanities subject from philosophy to history, the latter of which is of particular interest in this case. Digital history applies to the study and preservation of historical knowledge. It overlaps with the study of digital heritage, with heritage defined as “the study of human activity not only through the recovery of remains, as is the case with archeology, but also through tradition, art & cultural evidences, narratives, etc.” (Roussou, 2002). Digital heritage converts this study of human culture into digital form from analogue sources (UNESCO Charter art. 1). This conversion can take various forms. For example, many museums and historical institutions are in the process of digitizing their physical collections, making their resources available to the public through the Internet. Digital history can also take the form of geographic information system (GIS) projects, which are initiatives that track and visualize historical data and change over time onto maps. A third category – and the one that will be the focus of the following research – is that of virtual heritage.

2.1 Virtual Heritage and its Development

Virtual heritage (VH) is the recreation of historic sites or objects using techniques, such as computer-generated modeling, animation, and panoramic imaging. Its goals are to conserve, reproduce, and display history with the use of advanced technologies (Roussou, 2002). VH can also be described as a subset of the overarching field of digital heritage (Champion, 2008). It qualifies as digital heritage in that it is part of the study of history through the use of digital
technologies. However, it is a practice that distinguishes itself through the implementation of virtual reality (VR) and related 3D visualization techniques.

This practice first was used in the 1990’s and early 2000s and was often implemented by archaeologists. This makes sense considering the fact that some of the earliest modeling technologies could be found in CAD (computer aided design) programs, which were already being used by architects to make digitally rendered mock-ups of buildings. Archaeologists simply applied the same approach in order to create digital models of ancient buildings and historic sites under study. At this time, VH projects were the purview of research labs that could provide the specialized technologies and skills necessary for their creation. However, as technology has progressed the field is beginning to see new opportunities for wider application and innovative projects (Addison, 2000).

2.2 Virtual Heritage Technology

A number of technical approaches have been used over the past decade-and-a-half in the practice of VH when it comes to both creation and use. VH projects have been designed with the help of a number of 3D rendering programs over the years (Guidi, Frischer, & Lucenti, 2007). These include CAD programs, web-based virtual worlds such as Second Life, Blue Mars, and, most recently, video game systems such as the Unity game engine.

On the user side of VH, there are a number of possible technologies that can be used to give the public access to completed projects (Rahaman & Tan, 2009). These can offer a variety of user experiences and can differ depending on the context of use. For example, a museum might host a VH project as a part of an exhibit. The virtual world could be presented to the patrons through the use of a CAVE (Addison, 2000), a Computer-Aided Virtual Environment that consists of a room in which a virtual space is projected onto the walls, allowing visitors to be
physically immersed in a VH environment. VH recreations can also be used on a smaller scale similar in computer games. In this case, a project can be made available on a computer desktop either through an installed program or a website. A web-based project might allow for personal exploration by a single user or accommodate many users at a time, just as a massive multiplayer online game (MMO) would. On a more personal level, VH can also be accessed through the use of head-mounted displays (HMD), such as the Oculus Rift.

2.3 Three Categories of VH: Research, Preservation and Restoration, and Education

**Research:** VH can offer archaeologists and researchers the ability to study historic sites through detailed simulations. Roussou (2002) writes about how these simulations can be used to visualize alternative representations of a historic site in order to test researcher theories. Donald Sanders (2008), as well as Bernard Frischer and John Fillwalk (2012), are all practitioners with experience using VH in this way. For example, Frischer and Fillwalk describe the use of the Virtual Hadrian’s Villa Project in order to illustrate solar alignments with original Roman architecture. In order to recreate the alignments exactly as they would have appeared centuries ago, a computer model was necessary. Using data from NASA’s Horizon’s project, they were able to simulate the solar alignments that would have occurred on an exact day and time in order to demonstrate the way Romans designed their buildings in deference to solar cycles.

As president of The Institute for the Visualization of History, Donald Sanders worked on a number of VH projects as well. These include VH recreations of ancient Mediterranean shipwrecks. Sanders explains that 3D modeling allows researchers to examine the wreck sites without having to complete expensive diving expeditions. In a model of an amphora shipwreck they even created a simulation of the sinking that could be reset to test different positions of the cargo in order to try and understand how ancient ships used to be loaded. Sanders also points out
that 3D work on ancient architectural sites have helped researchers understand the building processes of ancient cultures. VH projects help researchers test theories about where and how a building might have been built and rebuilt over time.

**Preservation and Restoration:** Virtual heritage also allows historic sites to be preserved as 3D models. Currently, a leader in this kind of work is CyArk, a global organization with the mission of digitally preserving as many world heritage sites as possible. CyArk’s process includes the 3D laser scanning of national landmarks and historic sites, resulting in technical renderings and 3D maps and models that capture topical details and building dimensions. Conservators and researchers, as well as the general public, can then use these materials and media, either as visual aids and educational tools or as blueprints for conserving or reconstructing damaged historical sites. The goal of CyArk is to preserve heritage sites before they are lost to either natural or man-made disasters (Kacyra, 2011).

3D models can also be used in efforts to restore heritage sites. Katie Nodjimbadem (2016) of *Smithsonian Magazine* writes about actions being taken to recover from the terrorist destruction of world heritage sites in the Middle East. Spurred by the smashing of artifacts at Iraq’s Mosul Museum in 2015, archaeologists and other academics have come together to create “Project Mosul” (now called Rekrei) to create 3D renderings of the destroyed objects. These can be viewed online, in VR, and can be 3D printed. This is a very significant and current example of how VH can aid in historic preservation and restoration. It highlights a number of significant advantages to this kind of work: it allows people to view important sites, can aid specialists in repairing sites in case of future attack, could help officials identify artifacts looted and sold on the black market and could provide a record that could be referenced in future restoration efforts.
**Education:** Virtual Heritage projects also have the potential to be unique educational tools. VR can offer certain opportunities to see (and sometimes hear) history in action. A virtual space could be populated with non-playable characters (NPCs) like those seen in video games. These NPCs could be shown using or explaining how to use a historical object, much like an interpreter or guide would at a living history museum. This would provide an example of a piece of history in action by putting an object into the context of its actual use, going beyond a textbook explanation in a classroom. In general, VH applications can serve as a cheap way to travel to and study historic sites, offer a forum for student/instructor collaboration, and can bring the past back to life (Champion, 2008; Jacobsen & Holden, 2007).

### 2.4 Creating Context Through Cultural Learning

Increasing our understanding of the past and how to interpret it is the ultimate goal of VH. It can preserve historic spaces and rebuild long lost places. It can also tell the story of the eras during which these spaces existed and thrived. There is a growing movement in the world of VH to explore how to tell these stories and how to provide the historical context for a virtual environment. Part of creating historical context is to build VH projects that facilitate cultural learning. This encourages an understanding and connection to the past by putting the recreation within its place in history. This can be achieved by providing information about the building, site, or object, the kind of people who used it, and how it related to the culture of the era.

In the field of virtual heritage, researchers and practitioners are beginning to explore how 3D environments can be transformed into cultural learning opportunities in which users experience this connection to the past. Cultural learning can be characterized by the acquisition of knowledge that encourages cultural awareness and appreciation (Ibrahim, Mohamad Ali, & Mohd Yatim, 2015). Essentially, these practitioners attempt to determine how best to conduct
historical interpretation within a virtual space to place it in its historical context. Freeman Tilden (1957), one of the first to write extensively about historical interpretation as a professional practice, defined the term as, “an educational activity which aims to reveal meanings and relationships through the use of original objects, by firsthand experience, and by illustrative media, rather than simply to communicate factual information” (p. 8).

One of the key aspects to creating a comprehensive interpretation of digital heritage is that of cultural learning (Rahaman & Tan, 2011). Incorporating cultural learning opportunities into VH would help these projects surmount the separation of an object or place from its historical context (Flynn, 2007). One of the most outspoken advocates for virtual heritage interpretation is Eric Champion (2007). He is of the opinion that VH projects need to foster an understanding of cultural significance. However, they can’t achieve this goal when they only allow users to passively wander a reconstructed environment or are used, in Tilden’s terms, “simply to communicate factual information.” The ultimate goal is to allow users to see the environment the way the people of the time would have viewed it (Jacobsen & Holden, 2007).

Ibrahim, Mohamad Ali, and Mohd Yatim (2015) conducted a study to discover what factors contribute to the creation of a VH environment that facilitates cultural learning. They identified four factors: information design, information presentation, navigation mechanism, and environment setting. Information design is characterized as communicating information in a way that highlights its significance and relevance to the user. Information presentation is concerned with the presentation of information in a way that can be easily consumed by the user, such as layering and structuring information so that it is easy to sift through or using multimedia in order to communicate necessary information more effectively. The last two factors, navigation and environment, have less to do with providing information to users and instead assist users in their
exploration of the environment. Ibrahim, et al also discovered that user learning seemed to be best facilitated through the integration of meaningful information and effective information presentation.

A current goal of VH is to allow users to see reconstructed environments the way the people of the time would have viewed them. A way to do this is to incorporate cultural learning opportunities that provide context and understanding about the people and practices of the place in history that has been recreated. And, as the previous researchers discovered, these learning opportunities are best facilitated through the integration of meaningful information (Ibrahim, Mohamad Ali, and Mohd Yatim, 2015; Jacobsen & Holden, 2007) There are a number of possibilities when it comes to how this integration may be executed, some of which are demonstrated by existing VH projects.

2.5 Project Examples

A few virtual heritage projects have been developed in the past 10 to 15 years that try to integrate or populate computer-generated worlds with information that provides users with a greater understanding of the past. A couple of projects that exemplify this kind of work are the Apollo 11 Virtual Reality Experience and the Virtual Hadrian’s Villa Project, which was mentioned previously. Both go about this integration in different ways. The Apollo 11 project, which was created by Immersive VR Education Ltd., is a passive experience that users watch through a head-mounted display. During the experience, users experience the first moon-landing mission from the point-of-view of an astronaut. All the while, they are listening to oral history interviews from the astronauts, as well as NASA’s recordings of the dialogue between mission control and the astronauts, giving them an sense of authenticity during the experience.
The virtual Hadrian’s Villa Project was created by Indiana University’s Virtual World Heritage Laboratory in collaboration with Ball State University's Institute for Digital Intermedia Arts. This project is more exploratory in nature and represents a virtual recreation of the villa of Roman Emperor Hadrian. Users can enter the space as an avatar and explore the entirety of the villa. They can select certain interactive assets within the virtual space that link users to a digital archive that presents them with pictures and more information about the buildings and how they were used. The project also has a multiplayer version, which would allow multiple people to populate the virtual space. The feature is intended to support the project as a virtual learning classroom or a virtual living history museum in which a person could use an avatar as a costumed interpreter giving a tour to other people using the space (Khan Academy, n.d.).

Figure 2.1. This is a screengrab from a playthrough of the Virtual Hadrian’s Villa Project. Users can explore the villa alongside NPCs that populate the environment.

Both of these examples are VH projects that incorporate primary source materials into their 3D environments to help provide context. The Apollo 11 Experience incorporates original
audio, while the Hadrian’s Villa reconstruction is attached to web-based collection about the history of the archaeological site. This integration of historic collection and archival resources into VH has a lot of potential. The marriage of these two resources could be mutually beneficial, not only to provide primary sources that reinforce a VH recreation’s sense of place in history and aid in interpretation, but also to provide context to archival resources themselves. This would allow people exploring an archive to see and interact with the physical environment that the people in old photos and documents would have lived and worked in.

Although this literature review is not an exhaustive account of the entire VH landscape, it provides a baseline understanding of what VH is and its different uses in research, preservation, and education. This review also describes the current state of VH and how it is developing into the future, including a few examples of recent projects. This analysis is intended to impart an understanding of VBB and its relation to similar heritage projects and how it fits in with the development of the VH field. It is a VH experience that has both research and educational applications and tries to fulfill these goals by providing an interactive experience through which users can study and explore the reconstruction of a historic event.
3. Methods

The research design established for this thesis includes several key methods for assessing the user experience (UX) of the Virtual Buffalo Bill’s Wild West (VBB) project. UX focuses on the quality of a user’s interaction with a product or system (Nielsen & Norman, n.d.). Good UX is characterized by a system that users enjoy interacting with and that adequately meets their needs. This study has been designed to gather feedback about both users’ impressions of the VBB project in terms of user experience and general usability. The following sections detail the nature of the Virtual Buffalo Bill application, information about study participants and procedures, and study instruments and data collection methods.

3.1 Apparatus

The Virtual Buffalo Bill’s Wild West (VBB) project is a virtual heritage application sponsored by the Buffalo Bill Center of the West in Cody, Wyoming. A research and development team composed of members from the Institute of Digital Intermedia Arts (IDIA) Lab and the Center for Middletown Studies at Ball State University is responsible for its creation. The VBB project currently exists as a computer-rendered model of the Wild West exhibition, which was a circus-like spectacle that traveled across the U.S. and Europe from 1883 through 1908. The project presents the exhibition as it would have looked in 1899.

This virtual version of the Wild West show was created to illustrate a physical space that no longer exists. The Center of the West has a scale model of the show on display but was interested in creating an experience that was much more immersive and detailed than the model. The Center was also interested in exploring new ways to give people access to archival assets of the museum. Virtual Buffalo Bill provides an example of how this might be accomplished by
integrating archival photos into the virtual world and allowing users to access a digital archive website through in-world links.

These features are meant to encourage users to explore the source materials and historical content that are the foundation of the virtual recreation. These are the archival pictures, videos, documents, and objects and that tell the history of the Wild West exhibition. They were invaluable as reference materials during the reconstruction process and are also a key part of the finished project, providing users with primary sources to explore while they interact with the virtual environment.

3.1.2 Interactive Assets

VBB is a virtual world that users can explore, much like they would in a desktop-based video game. There are also several different assets that provide more context for what users are seeing, including a head-up display (HUD) feature that is integrated into the virtual environment. Users can navigate to certain points on the world map by selecting them (Figure 3.1). At those points, a HUD appears with either text and pictures explaining more about the recreation or videos that users can watch. Table 3.1 provides a description of each of these key features.
Figure 3.1. This image shows a VBB world map with each interactive asset numbered: 1) Home/Spawn Point, 2) HUD Asset – Train, 3) HUD Asset Videos (Backstage/Cast and Crew, 4) HUD Asset – Buffalo Bill’s Tent, 5) HUD Asset – Videos (Grand Review/Cowboy Fun), 6) HUD Asset – Indian Village, 7) HUD Asset – Video (Street Parade), 8) Grandstand – Show Animation. Users can select certain points on the world map to reveal either text and pictures explaining more about the recreation or videos that users can watch. Table 1 details the nature of each of the eight assets in this world map.

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<thead>
<tr>
<th>Asset #</th>
<th>Asset Title</th>
<th>Description</th>
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<tr>
<td>1</td>
<td>Home/Spawn Point: This is the starting point at which users first spawn into or enter the environment</td>
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<td>2</td>
<td>HUD Asset – Train: At this point a HUD appears with information about how the Wild West exhibition traveled from place to place as well as renderings of the train cars</td>
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<td>3</td>
<td>HUD Asset – Videos (Backstage/Cast and Crew): At this point a HUD appears which contains original film footage of the cast and crew setting up for a show. Two video clips are provided.</td>
<td></td>
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<tr>
<td>4</td>
<td>HUD Asset – Buffalo Bill’s Tent: At this point a HUD appears with information about Buffalo Bill and his duties as the show runner. An original picture of Buffalo Bill in front of his tent is included.</td>
<td></td>
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<tr>
<td>5</td>
<td>HUD Asset – Videos (Grand Review/Cowboy Fun): At this point a HUD appears which contains original film footage of acts in the show. Two video clips are provided.</td>
<td></td>
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<tr>
<td>6</td>
<td>HUD Asset – Indian Village: At this point a HUD appears with information about the Native American performers and their lives traveling with the show. An original picture of these performers is included.</td>
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</table>
HUD Asset – Video (Street Parade): At this point a HUD appears which contains original film footage of the Wild West street parade when the show visited New York City.

Grandstand – Show Animation: If users enter the grandstand they will see a looped animation of the Deadwood Stagecoach act in which Native Americans on horseback chase a stagecoach.

The web-based archive is another important interactive feature within the VBB experience. The archive serves as a repository for photographs of the show and other reference images. It can be accessed through the HUDs, each of which includes a link to the archive website where users can find more information.

![Figure 3.2. The home page of the web-based archive provides more information about the history of Buffalo Bill’s Wild West and its visit to Muncie as well a digitized collection of images and primary source materials.](image-url)
3.2 Participants

Fifteen Ball State University students (11 female, 4 Male) were recruited from undergraduate history classes and the general student population, especially those with an interest in American history. VBB is intended for use by an audience that varies in both age and interest. However, participants for this study represent a convenience sample of college students, one intended audience of the VBB application. It is important to note that ultimately, the VBB designers envision their end users to be members of the educated public with at least a mild interest in museums and history. They also hope that students studying United States history and the history of the American West will use this application.

3.2.1 Recruitment Procedures

A recruitment email (Appendix A) was first sent to select Ball State University history professors, who were asked to forward the email to their students and post it to bulletin boards in
the Department of History. This email was also sent to several relevant student groups, including the Ball State History Club and David Owsley Museum of Art Docents.

3.3 Study Procedure and Instruments

3.3.1 Setting

The principal investigator met with each participant individually and in person in a computer lab in the Department of Journalism at Ball State. Participants were provided with a desktop Mac computer in order to interact with the *Virtual Buffalo Bill* project.

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<th>Table 3.2</th>
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<tr>
<td><strong>Procedure</strong></td>
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<td><strong>Introduction to the System:</strong> Participants were given a very brief background about the Wild West exhibition, the introduced to the virtual recreation and instructed on how to use the navigation controls.</td>
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<tr>
<td><strong>Usability/UX Session:</strong> Participants were directed to navigate to certain sections of the application and explore the informational content provided. They were then allowed up to 15 minutes of free exploration of the system.</td>
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<tr>
<td><strong>Follow-Up Surveys:</strong> The principal investigator asked participants to complete two surveys: 1) a User Experience Questionnaire (UEQ) and 2) a System Usability Scale (SUS).</td>
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<tr>
<td><strong>Interview:</strong> The principal investigator conducted a post-session interview with each participant that included nine questions about the experience of interacting with the apparatus.</td>
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3.3.2 Introduction to the System

The principal investigator first explained the nature of the *Virtual Buffalo Bill* project and briefed participants about the actions they would be taking during the course of the study. It was explained that they would be exploring the project for a set amount of time, after that they would be given surveys to fill out and would be asked a few follow-up questions about their experience. The investigator also introduced participants to system controls and allowed them a few minutes to practice using them so they would become accustomed to the testing environment.
The principal investigator then read a script outlining how the participant should explore the VBB system (Appendix B). The investigator encouraged each participant to think aloud as they explored the project in order to comment on elements that they found particularly interesting or confusing.

3.3.3 Usability and User Experience Session

During the usability/UX session, participants were asked to visit three assets within the virtual world (locations 3, 5, and 6 marked on the world map). Then the researcher directed participants to navigate to the web-based archive where they could browse through the materials provided there. After they interacted with the assets as directed, they could explore the rest of the system freely for up to 15 minutes. During this time, the investigator observed participants’ use of the system while keeping track of which assets they interacted with and for how long. The computer screen was also recorded to assist in thorough data collection.

During each session, participants were directed to talk about their experience with the system as they were using it. This is a technique referred to as a think-aloud protocol. It is a method used to help a researcher understand users’ reactions to a system while they are interacting with it. The think-aloud protocol provides qualitative data that includes subjective impressions participants expressed in the moment of interacting with a system or product. It also generates positive or negative feedback about user interface, as participants will often remark on features they find difficult to interact with, as well as features they consider exciting, interesting, or helpful. Audio recording was essential to capturing think-aloud data, allowing user reflections to be transcribed and analyzed later to identify common themes. These remarks were also audio-recorded so they could be later transcribed and analyzed.
The investigator also kept track of how much time participants spent interacting with each asset they encountered. Recording time-on-task helps track how long it takes for a participant to complete assigned tasks. For this study, a time-on-task form was created so that the principle investigator could record how long participants took to read text, explore the archive, and watch video assets (Appendix C). A computer screen capture was also used to keep a visual record of participants’ interactions with the system. As this study’s aim is to determine the extent to which extent users interact with VBB, this quantitative data provided measurable feedback about user interaction.

3.3.4 Follow-Up Surveys

After a participant’s interaction with the VBB project was complete, the investigator provided two short surveys. These surveys were a System Usability Scale (SUS) (Brooke, 1996) and a User Experience Questionnaire (UEQ) (Laugwitz, Held, & Schrepp, 2008). The SUS is a validated instrument for analyzing the usability of an interface. Survey respondents are asked to rate how much they agree or disagree with statements about usability providing quantitative data about a system. This survey was used in this study to determine how easy or difficult it was for participants to interact with VBB. The SUS form can be found in Appendix D. The UEQ allows users to rate the system based on a number of subjective measures. These include such things as how enjoyable, attractive, or valuable participants feel a system is, to name a few. This survey was used to provide quantitative feedback about the VBB user experience. Figure 4 is an example of one dimension of the UEQ. The complete UEQ survey can be found in Appendix E.
Example:

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<thead>
<tr>
<th>attractive</th>
<th>☐</th>
<th>☒</th>
<th>☐</th>
<th>☐</th>
<th>☐</th>
<th>☐</th>
<th>☐</th>
<th>unattractive</th>
</tr>
</thead>
</table>

This response would mean that you rate the application as more attractive than unattractive.

Figure 3.4: The UEQ asks participants to provide feedback about several subjective measures of a system along a 7-point continuum.

3.3.5 Interview

The final portion of the UX study was a nine-question, semi-structured interview conducted by the principle investigator (Appendix F). Questions were designed to illicit qualitative feedback about overall user experience. It encouraged participants to discuss how effective VBB is in terms presenting content of informational value. Feedback generated by this interview provided a deeper understanding of the actions participants took during the test, as well as their impressions of VBB and its individual features.

Together these methods provide an opportunity to gather users’ feedback about the VBB project in terms of UX, as well as its general usability. This feedback yielded a substantial amount of data that is both quantitative and qualitative in nature. These results of the research activities outlined in this chapter are provided in the following chapter.
4. Results

The Virtual Buffalo Bill system was evaluated through a variety of usability and user experience methods. This chapter contains data collected from two surveys – the System Usability Scale (SUS) and User Experience Questionnaire (UEQ) – as well as Likert-scale interview questions. Additionally, transcripts from semi-structured interviews were coded to reveal common thoughts and opinions expressed by participants. The results from time-on-task tracking are also included.

4.1 System Usability Scale results

![System Usability Scale Scores](image)

*Figure 4.1. This graph illustrates final SUS scores for 15 participants in this study, which are represented by the blue line. The orange line marks the score a system must receive to be considered “average.”*

The SUS uses a ranking scale that encourages participants to rate how strongly they agree or disagree with a number of statements about the overall usability of a system. The average System Usability Scale score is 68 (Sauro, 2011). Systems that score above 68 are generally
considered to provide good user experiences. However, systems that fall below 69 probably have serious usability problems that should be addressed.

SUS scores for each of the participants in this study were recorded in relation to that average score (see Figure 4.1). Five participants ranked the system below that average, one participant ranked the system at an average score, and nine participants ranked the system above average. The highest score fell at a 97.5. It should be noted that the lowest score (32.5) ranked by participant 11 is most likely an outlier in this data set given that their score deviates far below the rest. It should also be recognized that the sample size for this survey is too small for these results to be statistically significant. However, this data does suggest that because most participants ranked the usability of the VBB system at, or above average, any usability problems that do exist are likely to be minor and/or easily addressed.

4.2 User Experience Questionnaire results

The UEQ measures the user experience of a system by having respondents rank how closely they felt certain adjectives described the system. There are 26 items on the questionnaire, and each item falls into one of six scales: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty (Schrepp, 2015). Table 4.1 defines each of these scales.

<table>
<thead>
<tr>
<th>Attractiveness</th>
<th>Overall impression of the product. Do users like or dislike the product?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perspicuity</td>
<td>Is it easy to get familiar with the product? Is it easy to learn how to use the product?</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Can users solve their tasks without unnecessary effort?</td>
</tr>
<tr>
<td>Dependability</td>
<td>Does the user feel in control of the interaction?</td>
</tr>
<tr>
<td>Stimulation</td>
<td>Is it exciting and motivating to use the product?</td>
</tr>
<tr>
<td>Novelty</td>
<td>Is the product innovative and creative? Does the product catch the interest of users?</td>
</tr>
</tbody>
</table>

*Table 4.1. There are 26 items on the questionnaire, and each item falls into one of six scales.*

The items are scaled on a range from -3 to +3. The lower of these two numbers represents the most negative score, 0 is a neutral answer, and +3 is the most positive score. The standard
The interpretation of UEQ scale averages implies that values greater than 0.8 represent a positive user experience evaluation and values less than -0.8 represent a negative evaluation.

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. Dev.</th>
<th>Left</th>
<th>Right</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>2.6</td>
<td>1.6</td>
<td>annoying</td>
<td>enjoyable</td>
<td>Attractiveness</td>
</tr>
<tr>
<td>2</td>
<td>1.9</td>
<td>1.6</td>
<td>1.2</td>
<td>not understandable</td>
<td>understandable</td>
<td>Perspicuity</td>
</tr>
<tr>
<td>3</td>
<td>1.6</td>
<td>1.7</td>
<td>1.3</td>
<td>creative</td>
<td>dull</td>
<td>Novelty</td>
</tr>
<tr>
<td>4</td>
<td>1.7</td>
<td>2.2</td>
<td>1.5</td>
<td>easy to learn</td>
<td>difficult to learn</td>
<td>Perspicuity</td>
</tr>
<tr>
<td>5</td>
<td>1.7</td>
<td>1.2</td>
<td>1.1</td>
<td>valuable</td>
<td>inferior</td>
<td>Stimulation</td>
</tr>
<tr>
<td>6</td>
<td>0.6</td>
<td>1.5</td>
<td>1.2</td>
<td>boring</td>
<td>exciting</td>
<td>Stimulation</td>
</tr>
<tr>
<td>7</td>
<td>1.4</td>
<td>2.1</td>
<td>1.5</td>
<td>not interesting</td>
<td>interesting</td>
<td>Stimulation</td>
</tr>
<tr>
<td>8</td>
<td>0.5</td>
<td>3.1</td>
<td>1.8</td>
<td>unpredictable</td>
<td>predictable</td>
<td>Dependability</td>
</tr>
<tr>
<td>9</td>
<td>-0.7</td>
<td>1.4</td>
<td>1.2</td>
<td>fast</td>
<td>slow</td>
<td>Efficiency</td>
</tr>
<tr>
<td>10</td>
<td>1.0</td>
<td>2.4</td>
<td>1.6</td>
<td>inventive</td>
<td>conventional</td>
<td>Novelty</td>
</tr>
<tr>
<td>11</td>
<td>0.9</td>
<td>1.1</td>
<td>1.1</td>
<td>obstructive</td>
<td>supportive</td>
<td>Dependability</td>
</tr>
<tr>
<td>12</td>
<td>1.6</td>
<td>1.3</td>
<td>1.1</td>
<td>good</td>
<td>bad</td>
<td>Attractiveness</td>
</tr>
<tr>
<td>13</td>
<td>1.6</td>
<td>1.7</td>
<td>1.3</td>
<td>complicated</td>
<td>easy</td>
<td>Perspicuity</td>
</tr>
<tr>
<td>14</td>
<td>1.3</td>
<td>1.4</td>
<td>1.2</td>
<td>unlikable</td>
<td>pleasing</td>
<td>Attractiveness</td>
</tr>
<tr>
<td>15</td>
<td>0.1</td>
<td>1.0</td>
<td>1.0</td>
<td>usual</td>
<td>leading edge</td>
<td>Novelty</td>
</tr>
<tr>
<td>16</td>
<td>1.3</td>
<td>0.9</td>
<td>1.0</td>
<td>unpleasant</td>
<td>pleasant</td>
<td>Attractiveness</td>
</tr>
<tr>
<td>17</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
<td>secure</td>
<td>not secure</td>
<td>Dependability</td>
</tr>
<tr>
<td>18</td>
<td>1.5</td>
<td>1.3</td>
<td>1.1</td>
<td>motivating</td>
<td>demotivating</td>
<td>Stimulation</td>
</tr>
<tr>
<td>19</td>
<td>0.9</td>
<td>2.9</td>
<td>1.7</td>
<td>meets expectations</td>
<td>does not meet expectations</td>
<td>Dependability</td>
</tr>
<tr>
<td>20</td>
<td>0.9</td>
<td>1.8</td>
<td>1.3</td>
<td>inefficient</td>
<td>efficient</td>
<td>Efficiency</td>
</tr>
<tr>
<td>21</td>
<td>1.4</td>
<td>2.7</td>
<td>1.6</td>
<td>clear</td>
<td>confusing</td>
<td>Perspicuity</td>
</tr>
<tr>
<td>22</td>
<td>1.0</td>
<td>1.9</td>
<td>1.4</td>
<td>impractical</td>
<td>practical</td>
<td>Efficiency</td>
</tr>
<tr>
<td>23</td>
<td>1.6</td>
<td>1.1</td>
<td>1.1</td>
<td>organized</td>
<td>cluttered</td>
<td>Efficiency</td>
</tr>
<tr>
<td>24</td>
<td>1.0</td>
<td>2.9</td>
<td>1.7</td>
<td>attractive</td>
<td>unattractive</td>
<td>Attractiveness</td>
</tr>
<tr>
<td>25</td>
<td>1.9</td>
<td>0.7</td>
<td>0.8</td>
<td>friendly</td>
<td>unfriendly</td>
<td>Attractiveness</td>
</tr>
<tr>
<td>26</td>
<td>1.0</td>
<td>2.1</td>
<td>1.5</td>
<td>conservative</td>
<td>innovative</td>
<td>Novelty</td>
</tr>
</tbody>
</table>

Table 4.2 This table contains the individual mean scores for every item on the UEQ. Each item is also paired with its corresponding scale. The standard deviation for each data point is also represented.

The average score for each item on the questionnaire can be found on Table 4.2. The standard deviation is also noted with the scores for each item. The standard deviation for most of the data in these results is high, indicating that the individual results from each participant were highly variant. This is due in part to having a small sample size of participants.
Figure 4.2 shows the combined average scores for each of the six scales. In this test, the VBB system was scored low in terms of its efficiency, dependability, and novelty. The system scored the highest on the scales for perspicuity, attractiveness, and stimulation. These results are also reflected in the benchmark comparison (Figure 4.4). This graph compares the scores from this test with a benchmark data set comprised of data representing 9,905 persons from 246 studies of different products. The comparison of the UEQ results for VBB with the data in the benchmark allows conclusions about the relative quality of VBB compared to other products.

Figure 4.2 Average scores for each of the six UEQ scales are represented on this graph. The black error bars are included to visually represent the range of variability in the data.
4.3. Time-on-task results

During the course of the study, each test session was timed. As participants interacted with the VBB application, the time they took to engage with each asset was recorded. Table 4.3
presents the average time participants spent interacting with each element of the application.

Participants were pretty active during their exploration, never interacting with one element for long. They often spent the most time exploring the archive or watching videos. Participants were also given up to 15 minutes of undirected exploration and on average people took 8:12 minutes to interact with the application as they wished.

<table>
<thead>
<tr>
<th>Task</th>
<th>Average Time on Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUD Asset 2 – Train</td>
<td>0:37</td>
</tr>
<tr>
<td>Archive Visit 1</td>
<td>1:53</td>
</tr>
<tr>
<td>Video Asset 5 – Grand Review</td>
<td>0:21</td>
</tr>
<tr>
<td>HUD Asset 6 – Indian Village</td>
<td>0:30</td>
</tr>
<tr>
<td>Archive Visit 2</td>
<td>1:25</td>
</tr>
<tr>
<td>HUD Asset 1 – Home/Main Menu</td>
<td>0:11</td>
</tr>
<tr>
<td>Video Asset 3 – Backstage</td>
<td>1:08</td>
</tr>
<tr>
<td>Asset 4 – Buffalo Bill’s Tent</td>
<td>0:08</td>
</tr>
<tr>
<td>Video Asset 7 – Street Parade</td>
<td>0:32</td>
</tr>
<tr>
<td>HUD Asset 8 - Grandstand</td>
<td>0:05</td>
</tr>
<tr>
<td>Other Exploration</td>
<td>8:12</td>
</tr>
</tbody>
</table>

Table 4.3. This table presents each asset that a person could interact with while using the application and the average duration of each interaction.

4.4 Semi-structured interview results

This study concluded with an open-ended, semi-structured interview. During these interviews, participants were asked four Likert-scale questions:

1. On a scale from 1-7 how easy was it to access the information in the web-based archive?
2. On a scale from 1-7 how easy was it to understand how to interact with the HUD interface?
3. On a scale of 1-7 how helpful was information provided in the HUDs and the archive at assisting you to learn about the Wild West exhibition.
4. On a scale from 1-7 how effective was the VBB project in encouraging you to want to learn more about the Wild West exhibition?
Participants ranked elements of their experience with the VBB project on a scale from 1 to 7 (with 1 representing the lowest answer possible: Not at all easy, effective, or helpful, and 7 representing the highest answer possible: Very easy, effective, helpful). Figures 4.5, 4.6, 4.7, and 4.8 depict how many participants chose each ranking. Figure 4.5 represents the results from the first question. All participants ranked this question positively, as all responses were either a 5 or above. The average score for this question was a 6.2. The second question (Figure 4.6) had responses at 4 and above. The lowest score for this question was a 2, although this response indicates a possible outlier. The average score for question 2 was a 5.6. The third question (Figure 4.7) was also mostly ranked at a 4 and above with a possible outlying score of 2 and an average score of 5.6. The last question (Figure 4.8) received a more varied response with all rankings falling at a 3 or above. The average for this question was also 5.6.

Figure 4.5. This table depicts the results to the first Likert scale question. Participants ranked the HUD interface in terms of ease of use. Most of the answers to this question fell between a 4 (neutral) and a 7 (very easy).
Figure 4.6. This table depicts the results to the second Likert scale question. Participants ranked how easy it was to navigate to the archive website. Most of the answers to this question fell between a 5 (somewhat easy) and a 7 (very easy).

Figure 4.7. This table depicts the results to the third Likert scale question. Participants indicated if the features helped them to learn more about the Wild West. Most of the answers to this question fell between a 4 (neutral) and a 7 (very helpful).
On a scale from 1-7 how effective was the VBB project in encouraging you to want to learn more about the Wild West?

![Graph showing the distribution of participants' rankings](image)

*Figure 4.8. This table depicts the results to the fourth Likert scale question. Participants ranked how effective the project was at encouraging participants to learn more about the Wild West. Most of the answers to this question fell between a 3 (somewhat ineffective) and a 7 (very effective).*

### 4.5 Coding

Audio from each user test session was recorded and transcribed. The transcripts were then coded according to an emergent coding scheme. Each statement was assigned a corresponding code that described that statement. A statement in this sense is defined as a complete thought expressed by a participant. Certain statements were identified as irrelevant and removed from coding. Irrelevant statements can be defined as any statements that were not representative of the objectives of the study.

There were 870 coded statements in total. Each statement was counted to determine how many participants expressed similar thoughts. The results of this data are illustrated in Table 4.4. Highlighted items on the table indicate the codes that were expressed by more than half of the participants in this study. The most common code, expressed by 14 out of 15 people, was that the video pop-ups lacked context or explanation. Other common codes include the enjoyment of exploring primary source materials as well as participant’s favorable impressions of the project.
<table>
<thead>
<tr>
<th>Feedback Gathered During Participant Interviews</th>
<th>Percent</th>
<th>N = Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impressed with the project as a whole</td>
<td>80%</td>
<td>12</td>
</tr>
<tr>
<td>Interaction with Head-Up Displays: Informational and video pop-ups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information was interesting and provided a good historical summary</td>
<td>20%</td>
<td>3</td>
</tr>
<tr>
<td><strong>Helped provide information about the 3D recreation</strong></td>
<td>73%</td>
<td>11</td>
</tr>
<tr>
<td>Information is straightforward and concise</td>
<td>47%</td>
<td>7</td>
</tr>
<tr>
<td>Liked that the HUDs immediately popped up</td>
<td>33%</td>
<td>5</td>
</tr>
<tr>
<td>Information pop-ups lacked affordances</td>
<td>53%</td>
<td>8</td>
</tr>
<tr>
<td>Information pop-ups were easy to interact with</td>
<td>73%</td>
<td>11</td>
</tr>
<tr>
<td>Participants enjoyed the videos as a primary source</td>
<td>67%</td>
<td>10</td>
</tr>
<tr>
<td>Video player lacks affordances</td>
<td>40%</td>
<td>6</td>
</tr>
<tr>
<td><strong>Videos lack context or explanation</strong></td>
<td>93%</td>
<td>14</td>
</tr>
<tr>
<td>Participants expected or wanted the videos to have audio</td>
<td>33%</td>
<td>5</td>
</tr>
<tr>
<td>Surprise that videos from that era were still around or existed in the first place</td>
<td>27%</td>
<td>4</td>
</tr>
<tr>
<td>Interaction with the Archive: Navigation to and exploration of the website</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants enjoyed the pictures and other primary sources</td>
<td>67%</td>
<td>10</td>
</tr>
<tr>
<td>Participants wanted transcripts for the documents in the collection</td>
<td>27%</td>
<td>4</td>
</tr>
<tr>
<td>Participants wanted more information about items in the archive</td>
<td>27%</td>
<td>4</td>
</tr>
<tr>
<td>Information is straightforward and concise</td>
<td>33%</td>
<td>5</td>
</tr>
<tr>
<td><strong>The archive was organized, easy to navigate and find information</strong></td>
<td>53%</td>
<td>8</td>
</tr>
<tr>
<td>The Archive was confusing to navigate</td>
<td>33%</td>
<td>5</td>
</tr>
<tr>
<td>Participants found the jump between 3D environment and archive website jarring/unexpected</td>
<td>53%</td>
<td>8</td>
</tr>
<tr>
<td>Participants suggested that the archive and 3D environment be combined</td>
<td>33%</td>
<td>5</td>
</tr>
<tr>
<td>Participants would not have known the archive existed without prompting</td>
<td>40%</td>
<td>6</td>
</tr>
<tr>
<td><strong>Lack of call to action or instructions to explore the web archive</strong></td>
<td>60%</td>
<td>9</td>
</tr>
<tr>
<td>Participants wanted it to be easier to switch between environment and archive</td>
<td>53%</td>
<td>8</td>
</tr>
<tr>
<td>Integration from 3D environment to archive was seamless</td>
<td>33%</td>
<td>5</td>
</tr>
<tr>
<td>Participants would have only found the archive through random exploration</td>
<td>47%</td>
<td>7</td>
</tr>
<tr>
<td>Informationally Valuable tool with Educational Applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants learned something new while using the program</td>
<td>60%</td>
<td>9</td>
</tr>
<tr>
<td>Inspired an interest to learn more</td>
<td>60%</td>
<td>9</td>
</tr>
<tr>
<td>Appeals to different learning styles</td>
<td>27%</td>
<td>4</td>
</tr>
<tr>
<td>Interesting, even to non-history buffs</td>
<td>33%</td>
<td>5</td>
</tr>
<tr>
<td>Provides information in a novel way</td>
<td>47%</td>
<td>7</td>
</tr>
<tr>
<td>Participants did not feel the need or interest to learn more</td>
<td>20%</td>
<td>3</td>
</tr>
</tbody>
</table>
Participants lose the overall context of the application | 40% | 6
Useful for researchers or a research project | 20% | 3
A good teaching tool | 33% | 5
A helpful visual aid | 20% | 3

**In-World Navigation: Map, Mouse, and Keyboard Controls**

Lack of map and location labels | 67% | 10
Participants can’t orient themselves on the map or in the environment | 40% | 6
Participants can’t remember where they have been | 20% | 3
Participants didn’t realize that they could navigate without the map | 40% | 6
Controls are overly sensitive – users can’t move with finesse | 53% | 8
Counterintuitive – controls are unfamiliar or don’t work as expected | 47% | 7
Participants become stuck while wrestling with controls | 20% | 3
Lack of affordances or instructions for what could be clicked on or explored and what could not

**In-World Interactivity and Sense of Presence**

Participants enjoyed exploring more of world | 60% | 9
Participants wanted more interactivity and activities like mini games | 33% | 5
Participants tried to enter tents to see what was inside | 53% | 8
Interest in narration or audio to accompany exploration | 13% | 2
Found exploration of the environment boring or unnecessary | 20% | 3
Participants want to interact and talk with the NPCs | 47% | 7
First person perspective gives participants the feeling that they are in the environment | 33% | 5
Participants experience the feeling that they are attending the show | 13% | 2
Participants were given a sense of the scale of the show | 33% | 5
Animation gives the environment life | 33% | 5
In-world textures were realistic and detailed | 47% | 7

Table 4.4 Lists the emergent coding scheme used to evaluate comments made by participants during their user test sessions. Each code is included with how many participants expressed that thought. Highlighted items indicate codes expressed by more than half the participants.

### 4.6 Limitations

It must be reiterated that these results are based on a limited data set and as such are not generalizable. Because of this, they cannot accurately reflect the usability or user experience of other similar virtual heritage applications. Further discussion and analysis of the results of this study can be found in the next chapter.
5. Discussion

This study was the first user experience and usability test of the *Virtual Buffalo Bill* project. The goal of this study was to evaluate the system and answer the guiding questions that are informed by the two main objectives of the project: 1) To what extent do VBB users explore the paradata materials used to inform the construction of the 3D models? 2) How effectively does the VBB experience engage users when it comes to learning more about the history of the Wild West exhibition and people involved in it? The results of this study help provide answers to these questions and inform possible areas of improvement in both user experience and usability.

5.1 To what extent do VBB users explore the paradata materials used to inform the construction of the 3D models?

This study yielded interesting results pertaining to the first guiding question about exploring paradata materials. Some of these materials and written information about them are integrated in the HUDs that pop up in the 3D environment. For example, the HUD that pops up in the Indian Village section of the environment contains a picture of some of the Native American performers and well as information about them (see figure 5.1). Most of these resources, however, are stored on a web-based archive that is linked within the environment. When asked whether they would have navigated to the archive website on their own and without prompting, the participants’ answers were often negative. There were 6 participants who said that they would not have known that the archive even existed. When asked whether they would have clicked on the “Archive” button, most participants said that they would out of curiosity to see what it did. According to this response, these participants did not recognize what this button would do or that it would open a different website.
This finding is reinforced by observed behavior during the test. During the study, over half of the participants indicated that they liked exploring the virtual environment. According to one participant “it’s cool because there are actually things to see other than the information, like you can wander through performance tents and there are people moving around and I enjoy that and think that’s fun”. This comment illustrates some of the elements of the environment that users found engaging.

On the other hand, time on task results show that the amount of time spent on the archive was inconsistent among participants when they were directed to go there. Some would just read the information that came up on the first page they were redirected to review when they clicked on the archive link. Then they would promptly return to the 3D world. Others were more interested in clicking on every menu item and reading the background information provided. When given free rein to explore the VBB project as they wished, none of the participants returned to the archive during the 15 minutes they were allotted. They did, however, explore the
in-world pop-ups and would travel to each marked location on the world map to see what was there. Participants seemed to be especially interested in the videos and remarked that they liked having primary source materials that they could watch.

Because one of the goals of the project is to encourage exploration of the historical materials this trend of not navigating to the archive is a potential problem. According to interviews with participants, a contributing factor seems to be that there is not a strong enough call to action or explanation that a lot of materials about the project and the history of the Wild West are stored on an outside website. This problem could be mitigated through the implementation of different labels for the “Archive” button (such as “More” or “Website”) or by letting users know as soon as they start using the application that the web-based archive is an option to explore.

There may also be other opportunities to encourage exploration of primary source materials. Behavior observed during the user tests showed that participants enjoyed navigating through the virtual world. Many would try to enter all the recreated tents and other structures in world to see if there was anything inside. There was also an expressed interest in interacting with the NPCs or for the NPCs to have dialogue options that would explain things about the recreation. A comment given during one of the test sessions reflects the kind of interaction that participants looked for while exploring the world: “This game reminds me a lot of RPGs [Role Playing Games] so I’m looking around with this video game mindset where I’m trying to see what things I can go into or interact with.” These behaviors and interests indicate possible opportunities for integrating more information users can access while they explore the application. More in-world structures could have informational pop-ups or objects that could be clicked on to learn more. NPCs could have short dialogue options that allow them to explain
their duties as a show performer or crewmember. It may be interesting to try integrating primary source information through mechanics that are in line with more exploration based (or even videogame-play based) behaviors.

5.2 How effectively does the VBB experience engage users when it comes to learning more about the history of the Wild West exhibition and people involved in it?

Results concerning the second guiding question about learning were predominantly positive. Nine study participants specifically indicated during their test sessions that they learned something new about Buffalo Bill or his Wild West exhibition. The same number of participants said that they wanted to learn more about the subjects, a couple going so far as to say that they would like to go home and do some further research. When asked to rank how effective the project was at encouraging participants to learn more about the Wild West, one provided the following response: “I think it’s very effective - this isn’t something that I’ve done a lot of research on or had a lot of classes on and I would like to learn more about it”. Participants’ answers to survey questions reinforced these findings. When asked if the information in the HUDs or on the archive was helpful in assisting them to learn more about the Wild West show, 12 of the 15 participants answered positively. Eleven people answered similarly when asked if they felt encouraged to learn more about the Wild West.

Participants also reported they enjoyed the inclusion of primary sources. These include the pictures and artifacts in the archive, as well as the pictures and videos contained in the HUDs. Participants were especially impressed with the videos playing original film clips from the show. According to one participant, the videos allowed them “to be able to directly see the stuff that was going on within the same environment”. During the test sessions 14 out of the 15 study participants expressed questions about the videos – what events they illustrated, what date
or where they were taken, who was in them, why they were included in the project – indicating a clear desire to learn more about them.

A number of participants also reported that Virtual Buffalo Bill would make for a good teaching tool. A couple of participants identified themselves as education majors and projected that the application would be interesting to integrate into lesson plans or to use as an effective visual aid. For example, one participant made the following comment: “I’m going to be a teacher so I thought something like this would be really cool if we were talking about Buffalo Bill and the Wild West I would be able to show this to my students and have them explore it.” Others also reported it would be a tool useful to researchers. This feedback indicates that people recognize that VBB has educational value and could be used in different learning scenarios.

### 5.3 System Usability

It was also one of the goals of this study to gauge the usability of the VBB project. Results suggest that the usability of the system was generally good. Participants could get the hang of interacting with VBB fairly quickly. However, the learning curve for first-time users can still be steep. Most usability issues appeared during the use of navigation controls, and when participants become confused due to the lack of usability affordances.

One such usability problem occurred during the navigation between 3D recreation and web-based archive. Half of the participants were surprised by the separation between virtual environment and website. Once first-time users clicked on the archive link, they had no forewarning that they would be taken into a very different browser window. Eight participants indicated surprise or confusion the first time this happened and sometimes expressed worry that they had clicked on something wrong. For example, one participant commented: “If I did click on “archive” [without being prompted] I feel like I would immediately be confused by the
second window popping up and would have though I accidentally navigated away or broke it if I didn’t know that’s what was supposed to happen”. After they overcame this confusion, they could be hesitant and unsure of how to navigate back to the environment and would indicate this to the test proctor by asking if they were performing the right action or clicking on the correct icon. This confusion suggests that it would be worth exploring options for making the switch between interfaces easier or less of a surprise.

Usability issues also arose when the head-up displays lacked some basic affordances. For example, this early version of the application includes no location indicators in the environment (aside from those on the map) that can be clicked on to call up the HUDs. This leads users to rely on the map to access the HUDs or hope they hit just the right spot while exploring the environment to bring them up. For example, one participant exited out of a HUD before they were finished reading it and was confused about how to get it to pop up again. They tried moving their position in world to hit the right spot to activate the HUD with little success. They then had to open the map and select the location icon to travel to the correct spot to bring up the information. Once these pop-ups are called up, the HUDs that contained text do not have scroll bars to indicate that there is more information below the cut. Participants could use the scroll wheel on their mouse to move through the text but in some cases, it was hard for them to recognize that there was more text to read, a problem that could be avoided with the addition of a simple scroll bar.

The videos that popped up in world also lack certain crucial elements. There are no play/pause buttons on the video players. This led to confusion among participants who tried to figure out how to stop the video playback before they closed the pop-up window. There are also no scrubber bars on the video players, which led many to wonder just how long the videos are.
Finally, there is nothing to indicate that almost all the video pop-ups play a different video each time a user calls one up which can result in users missing important content.

There were also a few issues with the navigation within the virtual environment of VBB. In this version of the application the click and drag controls were very sensitive, meaning that study participants had a hard time using them to explore the environment. Furthermore, the click-and-drag feature was counterintuitive for most people. Many participants were observed trying to drag the screen in the opposite direction they wanted to look in order to change the view angle. It seemed they were expecting the controls to work as they do in an app such as Google Maps or in computer games they were more familiar with. One participant commented that they kept expecting the controls to work like they do in the game Minecraft. This wasn’t the only source of disorientation. The world map has points to indicate locations that users can fast travel to. However, these points are not labeled meaning that study participants sometimes expressed confusion about where they were in the environment. Adding location labels could help cut down on this confusion while helping the user learn more about the parts of the Wild West exhibition.

The navigation between the 3D world and website, the lack of affordances, and confusion over navigation are the three biggest usability issues identified in this study. These issues did not completely impair the usability of the system and did not prevent any participants from finishing a testing session. Despite initial confusion, most were able to get the hang of interacting with the application once they knew what to expect. Although participants could understand how to interact with the system’s features and controls, there still was a learning curve. A few participants suggested similar solutions to get over this curve: either a videogame-like intro that
briefly introduces the controls and the options for interactions, as well as in-world markers or signs that indicate what can be clicked on to open more information.

A game intro could also possibly solve another interesting issue noticed during testing: people seemed to lose the context of the project. This means they tended to lose sight of who and what the project was about as well as the fact that the recreation was set specifically in Muncie, Indiana. Now, part of this is probably due to the fact that the testing of VBB for this study removed it from a more realistic context of use i.e. a scenario in which it is used as a research or learning tool. However, an introduction screen would be a possible place to provide a brief background about the who, where, and why of the recreation as well as a primer on the navigation controls.

5.4 Limitations

There are certain limitations that must be taken into account when reviewing the results from this study. First, these results are not generalizable, as they are based on a limited data set. More participants would have yielded more feedback overall which would have resulted in more statistically significant data. Also, one of the interview questions was misinterpreted to mean “how easy is it to use the archive website” instead of the more accurate “how easy was it to get to the website from the environment.” This accounts for the discrepancy between the positive answers for this question and the negative reactions participants gave during the walkthrough and during the interviews. It should also be noted that participants spent an inconsistent amount of time on the archive website, making it difficult to draw any solid conclusions about its usability from this study.

5.5 Conclusion and Future Work
This study explored how one VH application connects its user to historical source materials. VBB attempts to do this through the integration of these materials within heads-up displays and through the integration of a web-based archive that users can access through the application. This evaluation of the system explored the efficacy of such a novel approach to the integration of Internet content in the form of a web-based archive and digital collection. The results indicate that people enjoyed having access to interesting primary source materials while exploring the VBB project. These include both the pictures and videos on the HUDs and the photos and artifacts in the digital collection. They helped add depth and a sense of verisimilitude to the project by tying computer rendered models to the original images and information about the exhibition and the people who worked there. It is also clear that people enjoyed exploring the recreation on their own terms and wanted even more to explore, if possible. Adding new areas to explore, objects to interact with and study, and characters that could be talked to and learned from are all things participants in this study expressed an interest in seeing added in future versions of VBB. This also provides suggestions for what may be worth exploring in similar VH projects.

The *Virtual Buffalo Bill’s Wild West* project should continue to be tested as features and functionality are updated. It would also be advisable to test the usability of the archive website as its own entity. This would allow for clear feedback about any changes that should be implemented to the site itself. It’s highly suggested that any further testing of either the website or the virtual environment be conducted with more participants to yield more generalizable data. Future testing should also include a context of use. This means if the developers wish to understand how a teacher would use this application with students then the participants of that study should be either students or teachers. Another possibility for further evaluation would be to
run a comparative study in which the Virtual Buffalo Bill project is tested alongside other similar projects to see how it measures up to other virtual heritage applications.

This study is an important first step in evaluating the VBB project. It has helped to generate valuable insight and feedback about the prototype. This contributes to a greater understanding of the current state of the project in terms of what features work and what can be improved. As these improvements are made and as the project develops further more testing should be conducted in order to ensure that Virtual Buffalo Bill achieves its goals of encouraging its users to learn about and explore history.
Works Cited

Appendix A

Participant Recruitment Email

Hello:

My name is Erin Bretz and I am a graduate student from the Emerging Media Design and Development program looking for volunteers for a user experience study. I am evaluating an early version of the Virtual Buffalo Bill project (http://idialab.org/virtual-buffalo-bill/), which requires further user testing and feedback. I hope that you will consider participating in this study.

Each user test session will last for about one hour and will be conducted on campus in room AJ 390. Sessions will be held most weekday evenings after 5 pm. For the study, you will be asked to engage with the Virtual Buffalo Bill website and respond to questions related to usability and user experience.

This study is open to those between the ages of 18 and 60. Participation is voluntary and confidential. You do not need to bring anything to the test session or prepare in any way.

If you are interested, please let me know if you are available. Contact me at eebretz@gmail.com in order to reserve a test session time.

Thank you very much,
Appendix B

Usability Testing Script

Introduction:

This is the Virtual Buffalo Bill project. It is a 3D reconstruction of the Buffalo Bill Wild West Show which was a circus-like spectacle which featured the exploits of cowboys and Indians as it traveled across the U.S. and Europe from 1883 through 1908.

This reconstruction will show you how the Wild West Show looked in 1899 when it visited Muncie. It also supplies background information about the performance and its cast and crew.

I’ll give you quick overview of what you will be doing today - first I will introduce you to the navigation controls for the system, then I will give you a few tasks and allow you to explore.

After your interaction with the project is complete I will give you 2 short surveys to fill out and then ask you some interview questions.

I will be recording what is happening on the computer screen. I will also record audio of your usability session. However, your name and other identifying information will not be included in the audio or resulting transcripts. Likewise, the audio recordings will not be used for any formal presentations or public reports of the data.

Introducing the controls:

Now I am going to introduce you to the system controls.

The arrow keys on your keyboard will allow you to move your position left, right, forwards, and backwards.
If you want to change the view angle you can drag the mouse cursor in the direction you want to look. So, drag right to look right, drag left to look left and so on.

There are also a few icons in the top right of the screen, one of which brings up a map of the environment that looks like this (Refer to Diagram). You can click on any circle on the map to travel to that location.

I will give you a couple minutes to move around in the environment to practice with these controls. Let me know when you feel as if you have a good handle on how to move through the environment and then we can move on to the next part of the test.

**Directions:**

Next, you will use the map and directional controls to move around the environment and interact with the informational content.

I would like to remind you to take your time as you explore the environment and its content.

Please know that this is a test of the VBB system, not a test of your abilities. Because of this, I encourage you to talk aloud as you use the system, especially to remark on features that are interesting or confusing.

Also, be aware that this is a beta version of this program. Because of this, certain functions may not work as expected.

If you have any questions during your experience you may direct them to me. We can begin if you have no questions for me before we start.

**Tasks:**
I would like you to navigate to these 3 locations using the map (refer to map diagram). I will have you start by going to Location 2

**Location 2** – Once you get there, you may read through the information provided in the display if you wish.

After you are done with that click on the “Archive” button in the lower right. Once on the Archive website you can explore for as long as you like.

**Location 5** – okay, if you are done exploring the archive go back to the virtual world and click location 5 on the map. Once there you may look at that content for as long as you like.

**Location 6** – Okay, if you are done here go ahead and click on location 6 on the map. Once there, you may read through the information provided in the display if you wish.

After you are done with that click on the “Archive” button in the lower right. Once on the Archive website you can explore for as long as you like.

**Open Exploration** – Now that you have finished interacting with these 3 locations and the archive you may explore the rest of the reconstruction as you wish for up to 15 minutes. Remember to keep talking aloud about your experience.
Appendix C

Time on Task Form

User ID: _______   Start Time: _______   End Time: _______

Researcher: Record the number of minutes/seconds the participant spends on each task.

<table>
<thead>
<tr>
<th>Task</th>
<th>Time on Task/Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUD Asset 2 - Train</td>
<td></td>
</tr>
<tr>
<td>Archive Visit 1</td>
<td></td>
</tr>
<tr>
<td>Video Asset 5 – Grand Review</td>
<td></td>
</tr>
<tr>
<td>HUD Asset 6 – Indian Village</td>
<td></td>
</tr>
<tr>
<td>Archive Visit 2</td>
<td></td>
</tr>
<tr>
<td>HUD Asset 1 – Home/Main Menu</td>
<td></td>
</tr>
<tr>
<td>Video Asset 3 – Backstage</td>
<td></td>
</tr>
<tr>
<td>Asset 4 - Tent</td>
<td></td>
</tr>
<tr>
<td>Video Asset 7 – Street Parade</td>
<td></td>
</tr>
<tr>
<td>HUD Asset 8 - Grandstand</td>
<td></td>
</tr>
<tr>
<td>Other Exploration</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

The System Usability Scale (SUS)

**Instructions:** For each of the following statements, mark one box that best describes your reactions to the system you engaged with today.

<table>
<thead>
<tr>
<th>Usability Scale</th>
<th>Strongly Agree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I think that I would like to use this system frequently.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I found the system unnecessarily complex.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I thought the system was easy to use.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I think that I would need the support of a technical person to be able to use this system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I found the various functions in this system were well integrated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I thought there was too much inconsistency in this system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. I would imagine that most people would learn to use this system very quickly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I found the system very cumbersome to use.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. I felt very confident using the system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. I needed to learn a lot of things before I could get going with this system.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please provide any comments about the system:
Appendix E

User Experience Questionnaire

Please make your evaluation now.

For the assessment of the product, please fill out the following questionnaire. The questionnaire consists of pairs of contrasting attributes that may apply to the product. The circles between the attributes represent gradations between the opposites. You can express your agreement with the attributes by ticking the circle that most closely reflects your impression.

Please decide spontaneously. Don’t think too long about your decision to make sure that you convey your original impression.

Sometimes you may not be completely sure about your agreement with a particular attribute or you may find that the attribute does not apply completely to the particular product. Nevertheless, please tick a circle in every line.

It is your personal opinion that counts. Please remember: there is no wrong or right answer!
| Annoying | Not understandable | Creative | Easy to learn | Valuable | Boring | Not interesting | Unpredictable | Fast | Inventive | Obstetric | Good | Complicated | Unlikable | Usual | Unpleasant | Secure | Motivating | Meets expectations | Inefficient | Clear | Impractical | Organized | Attractive | Friendly | Conservative | Enjoyable | Understandable | Dull | Difficult to learn | Inferior | Exciting | Interesting | Predictable | Slow | Conventional | Supportive | Bad | Easy | Pleasing | Leading edge | Pleasant | Not secure | Demotivating | Does not meet expectations | Efficient | Confusing | Practical | Cluttered | Unattractive | Unfriendly | Innovative |
Appendix F

Semi-structured Interview Questions

1. On a scale from 1-7 (1 = “not at all”, 4 = “neutral”, and 7 = “very”) how easy was it to access the information in the web-based archive? Please explain.

2. On a scale from 1-7 (1 = “not at all”, 4 = “neutral”, and 7 = “very”) how easy was it to understand how to interact with the HUD interface? Please explain.

3. On a scale of 1-7 (1 = “not at all”, 4 = “neutral”, and 7 = “very”) how helpful was information provided in the HUDs and the archive at assisting you to learn about the Wild West Show. Please explain.

4. On a scale from 1-7 (1 = “not at all”, 4 = “neutral”, and 7 = “very”) how effective was the VBB project in encouraging you to want to learn more about the Wild West Show? Please explain.

5. Did your interaction with the 3D environment encouraged you to explore the information provided in the HUDs and the archive? Please explain.

6. Do you think the archive and its content could be improved in any way? If so, could you explain?

7. Were there any elements of this experience that were more interesting to you than others? Please explain.

8. Would you have navigated to the web-based archive had you not been prompted to do so? Please explain.

9. Is there anything else you would like to tell me about your experience today?