

VIRTUAL REALITY-BASED EXPERIENTIAL MODEL FOR LOST HISTORIC
BUILDINGS

A Thesis

by

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ABSTRACT

Historic buildings have always been facing severe threats of destruction. Historic buildings are the physical links to our past, and help in forming and imprinting a cultural memory within us. However, when a building gets totally destroyed, the resources available to learn about the past are very limited. The archaeological relics, photographs, sketches, textural records, etc. fail to create a complete picture of the lost structure in our mind due to their unorganized nature and lack of possibility to explore in and around the building.

Virtual reality (VR) is an interactive technology that allows people to virtually walk inside built environments using digital tools, and enables us to experience them on a human scale. Virtual heritage (VH) applications have been a popular research area among the Architects, Archaeologists and Historians for more than two decades. Virtual heritage projects, excluding projects developed in the entertainment industry, are predominantly developed by researchers and academicians. These virtual heritage projects mainly focus on either the 'Process' (3D reconstruction mechanism) or the 'Products' (Virtual Reality systems) but do not consider the end-users, i.e. the 'People' going to use the system. Humans are cultural organisms and their cultural and demographical aspects differ from each other and hence the cultural interpretation, perception and reaction are subjective. Different cultural environment poses different meanings to different people. Hence, it is crucial to identify what end-users' interests are in a virtual heritage environment in order to effectively educate about the past. This research attempts to investigate the experiences of users when a first-person Virtual Reality-based model of a lost building is presented to the visitors of the museum.

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NOMENCLATURE

2D	Two Dimensional
3D	Three Dimensional
AR	Augmented Reality
BIM	Building Information Modeling
HMD	Head Mounted Display
ICT	Information and Communication Technology
VR	Virtual Reality
VH	Virtual Heritage

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CHAPTER I

INTRODUCTION

Historic buildings serve as a great source of information and play a crucial role in learning about the past. Historic buildings are the exposed evidence of the past and help in forming and imprinting a cultural memory within us. Its ability to promote experiential learning allows people to personally experience the space and learn about the architectural style, building functions, spatial configuration, aesthetics, building materials, textures, building fixtures, furniture, etc. Further, the historic buildings serve a wide range of individuals including students, architects, construction professionals, archaeologists, educationalists, conservationists, historians, tourists, filmmakers, etc. Hence, the historic built environment is considered a great teaching tool because of the reason they promote experiential learning process. Experiential learning is the concept of getting out of the textbooks and using the surrounding physical environment in the learning process (Jose, Patrick, & Moseley, 2017). In the built environment, experiential learning strategy allows people to experience the built environment personally, and engage them with the context of interest. From this, we learn, historic buildings are critically important to support learning about the past.

However, historic structures are continuously threatened by terror activities, climate change, urbanization, and exploitation by tourism, and in many cases, by poor maintenance and preservation strategies (Abdelmonem, 2017). Historically, buildings have been facing severe threats of destruction due to various human and natural causes. Some of the causes of destruction are natural disasters, lack of maintenance, pollution, erosion, urbanization, vandalism, aging, etc. More than 2000 historic buildings got destroyed during the recent earthquake in Mexico in 2017.

In the last two years, more than 100 historic buildings have been destroyed in Iraq and Syria due to the act of vandalism by the local militant groups. According to UNESCO, there are around 56 World Heritage sites that are in the danger of destruction. Several thousands of such cases of destruction of historic buildings have been witnessed in the past.

While historic buildings serve as a great tool to learn about the past, when a building gets destroyed, the resources available for the future generations to learn about the past are very limited. These resources include textual records, sketches, previously taken photographs, ruins, scaled models, etc. In most cases, these resources are preserved in the museums. Observing textual records, scaled models, ruins and graphical content provide very limited opportunity to gain a good understanding of the lost structure, and is less efficient as a teaching tool. This is due to the reason that the resources available in the museums provide no opportunity for experiential learning. These unorganized resources do not allow people to interact in and around the built spaces, and it is difficult to connect all the information and create a whole picture of the lost building in our mind. Also, the amount of information available in the museums are not sufficient enough to correlate and form a complete picture of the lost building within us.

Previous studies have identified that simulating the real experience is more efficient as a learning tool compared to reading, listening or watching exhibits. Virtual Reality is a popular technique to simulate the real experience. Also, virtual reality technology has been tremendously benefiting the built environment education. Keenaghan and Horváth (2014) reviewed how built environment education has benefited from the rapidly growing VR technology adoption. In the past, there have been several works that attempted to develop Virtual Heritage applications, and it has been widely accepted by the researchers that Virtual Reality-based heritage tools are effective as an education tool. Virtual heritage is an interactive technological application that attempts to

transfer the experience of historic buildings, cultural landscapes, urban spaces, etc. into an engaging experience for the ordinary people to learn about the cultural significance of the past (Abdelmonem, 2017). In the past 10 – 15 years, virtual heritage projects has been mainly focusing on new ways of recreating history and built environment in the virtual environment (Bretz, 2017). These projects mainly focus on the ‘product’ and the ‘process’ but do not consider the ‘people’, i.e. the end-user. The product deals with the virtual reality system and the process deals with the virtual reconstruction of cultural heritage. ‘People’ is the most important factor in developing a successful virtual heritage environment to educate about the past. However, this factor is often ignored by the researchers, probably due to the reason that the product remains within the purview of research and academia. It must be noted that Digital Heritage applications are developed for an end-user. And it is unclear what an end-user needs in the VH environment. Tan and Rahaman (2009) argue that physical aspects and cultural aspects influence the users’ experience in a virtual heritage environment. For example, an artifact may be viewed as an important aspect by one user but not by another user. Humans are cultural beings and the difference in the cultural and demographical background would affect the perception and interpretation of a cultural object (Rahaman & Tan, 2011). In the past, there has been a very little research done to understand the elements that contribute to the learning of cultural heritage among the users of VH environments (Ibrahim, Mohamad Ali, & Mohd Yatim, 2015). Hence, there is a need to investigate the end-user interests in virtual heritage learning environments.

Research Problem

Historic Buildings serve as a great source of information and play a major role in supporting the learning process. Its ability to promote experiential learning allows people to personally

experience the space and learn about the past. However, historic buildings have always been facing severe threats of destruction, and have got lost due to various reasons. The existing way of presenting information about lost buildings through repositories like the museum is not efficient as a teaching tool as there is no opportunity to explore in and around the lost building. Virtual Reality-based cultural heritage applications can be implemented as a complementary method to teach about the past. However, in order to develop a successful VR-based learning tool for lost historic buildings, it is required to keep the end-users engaged in such digital applications. Hence, it is imperative to identify what the end-user interests are in a VR-based learning environment for lost historic buildings. The end-users' interests vary greatly based on their cultural background, knowledge about the particular building, previous experience in using the digital tools, age, technical skills, learning ability, cognitive skills, etc. Hence there is a need for continuous evaluation of end-users' interests to identify what they would like to experience in the Virtual Heritage environments. Continuous evaluation of end-users' interests in virtual heritage environments would help to develop a more inclusive educational tool.

To sum up, the problems that the current research trying to address is as follows:

- Lack of sufficient resources to understand the elements from the perspective of the people in first-person virtual heritage environments.
- Research in the domain of virtual heritage environments predominantly focuses on the evaluation of the product (virtual reality systems) and the process (Data acquisition and 3D reconstruction techniques).
- Lack of opportunity provided to the research participants to experience a traditional way of learning about a lost building, while experiencing a virtual reality-based heritage system.
- Lack of effort made to present the developed virtual heritage products to casual learners.

Motivation

While the museums contain different types of learning resources like textual records, sketches, building ruins, photographs, scaled models, etc. to learn about the past, visitors may hardly appreciate the built environment created in the past. One may appreciate and learn about the past more effectively when he or she gets a chance to step into the actual building.

When it is unrealistic to reconstruct the old building, a three-dimensional (3D) computer model can be used instead to visually represent the lost building. Theoretically, simulating the real experience is efficient as a teaching tool compared to reading the text, watching pictures and exhibits (Dale, 1969). Further, our experience of browsing a 3D computer model is enhanced when we can feel a sense of presence while walking through the model. Previous research in the area of information technology indicates that Virtual Reality (VR) technology would enhance our experience in exploring a 3D computer model. It is therefore reasonable to expect that those museum visitors who are exploring the first-person virtual reality model of lost historic buildings using a Head Mounted Display (HMD) can better figure out the building's interior configuration, architecture style, materials, and other historical information associated with the lost structure because learning by doing is easier than learning by just reading and watching (Dale, 1969).

Virtual Reality can enable people to explore any virtually constructed space at a human scale and hence can supplement the requirement for experiential learning. The interface design could transform the VR environment into an educational tool that could promote the learning process. Further, VR technology supports Telepresence and Distance Education. While it has been widely accepted by the researchers that virtual reality enhances users' understanding about cultural heritage and lost buildings, there is a wide knowledge gap in the domain of end-users' opinions

and perspectives in virtual heritage environments (Ibrahim et al., 2015). Since the users' perspective greatly varies upon the various factors like culture, demography, knowledge about the lost building, technical skills, etc. (Mosaker, 2001). Hence, there is a need for continuous evaluation of end-user' opinions and perspectives to identify the nature of cultural and historical information, and the mode of presentation preferred by end-users in first-person virtual heritage environments. Considering the fact there is a wide knowledge gap in this area, and continuous evaluation is required, it can be understood that significant research contribution can be made in this discipline. This is the motivation for my research.

Research Objectives

The main research objective is to investigate the end-users' experience of a Virtual Reality-based experiential learning tool and identify the factors contributing towards their cultural learning experience in a first-person virtual heritage environment. The following tasks will be followed to achieve the objectives of the research:

1. Development of VR-based Experiential Model of a lost historic building – 3D Model, First-Person VR, Information Dissemination.
2. Evaluation of user experience using a qualitative research methodology.

Limitations

This research study will not investigate the efficacy of the Virtual Reality system. But it attempts to identify what factors contribute towards the end-users' learning experience in first-person VH environment. Also, this research will not attempt to assess the user's knowledge acquisition and retention capability using the VR system developed for this study.

CHAPTER II

LITERATURE REVIEW

Virtual Reality

The concept of virtual reality (VR) emerged about half a century ago in the form of stereo head-mounted display (HMD), tracking, and graphics (Slater & Sanchez-Vives, 2016). Today, virtual reality technology has reached the attention of the general public, and this disruptive technology is hailed by scientists, researchers, academicians, celebrities and business people. Virtual reality attempts to simulate a targeted behavior in an organism. Simulations are interactive learning tools that mimic a real-life situation (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). Simulations can promote the cost-effective practice of process and procedures utilizing digital technologies that in the real world could be expensive. Simulations are beneficial because they let people practice and acquire skills that otherwise could be extremely unsafe to perform in real-world condition.

Virtual Reality in Education

Numerous research studies have been performed on the use of VR technology in education and training. This section of the literature presents some of the findings relevant to the usage of adopting virtual reality in education. (Youngblut, 1998) studied the educational uses of virtual reality in the 1990s and attempted to present the effectiveness of VR technology in kindergarten through grade 12 education. Numerous studies have attempted to identify how children interact

and learn in a three-dimensional environment. (Pantelidis, 1995) discovered the following reasons to use virtual reality in education:

- Virtual reality promotes visualization, focusing on the merits of visual representations. It supports an alternate way of presenting a material.
- Virtual reality highly motivates students.

Kavanagh, Luxton-Reilly, Wuensche, and Plimmer (2017) presented a systematic review of using virtual reality in education and reported the issues and limitations as well. VR environments are facilitated with distinct features like to promote shared experiences, natural user interaction and tailor unique learning experiences to meet individual users' needs make the interactive technology highly suitable for learning (Fabola & Miller, 2016). The continuously growing popularity of the VR technology for learning was investigated and presented by Mikropoulos and Natsis (2011) that present a review of empirical studies performed on the application of using VR for learning from the year 1999 to 2009. The use of immersive virtual reality has been considered a beneficial strategy for architectural design (Paes, Arantes, & Irizarry, 2017). Despite the capacity of VR technology to rebuild and enhance real and virtual environments, many applications in Archeology domain focus on the photorealistic presentation of architectural elements and spaces (Pujol-Tost, 2017).

Virtual Reality in Heritage Learning

Virtual heritage (VH) is generally described as the creation of historically and culturally significant environments and objects utilizing three-dimensional models and virtual reality technology. Virtual heritage is the amalgamation of virtual reality technology with historical and cultural heritage content (Addison, 2000). Abdelmonem (2017) defines virtual heritage as an

interactive technology that aims to transfer the experience of historic buildings, cultural landscapes, and urban spaces into an engaging experience for the ordinary people. The practice of Virtual Heritage was first used in the 1990's and early 2000s and was primarily adopted by archaeologists (Bretz, 2017). The application of virtual reality technology is continuously spreading in museums and cultural heritage settings, promoting public education (Economou & Pujol, 2006). In recent years, the growth potential of visualization technologies has started to be leveraged in the Cultural Heritage domain (Dagnino, Pozzi, Cozzani, & Bernava, 2017). In general, VH applications can serve as a cost-efficient way to travel to and study lost heritage sites and can help relive the past. (Champion, 2010). The goals of Virtual heritage environments are to conserve, reproduce and present history utilizing advanced technologies (Roussou, 2002).

Virtual Museum is an alternative to a museum in digital form with virtually the same aim as a real museum which is to showcase a museum's collection, in turn, to provide knowledge to visitors through informal learning (Rahim, Wook, & Zin, 2017).

Virtual Heritage Projects and Project Aims

According to Bretz (2017), during the recent 10 to 15 years, VH projects have been focusing on new methods to recreate the historic environment in the virtual environment. Virtual heritage projects can be categorized into three areas: Research, Preservation and Restoration, and Education (Tan & Rahaman, 2009). While all the virtual heritage projects can be categorized these three categories, the VH projects widely differ in terms of research and project aims like investigating the effectiveness of Information and Communication Technology (ICT) medium (AR, VR, Web content, etc.), usability of the VH system, experiences with display devices, process of developing

VH systems, data acquisition & 3D Reconstruction techniques (Photogrammetry, Laser Scanning, 3D Modeling, Building Information Modeling), etc.

Fabola and Miller (2016) investigated the application of Virtual Reality as a tool for cultural heritage learning, using the virtually reconstructed model of St Andrews Cathedral, a partially destroyed 14th Century structure. This study primarily investigated the experiences of school students in virtual heritage environment with various VR systems including Samsung Gear VR, Google Cardboard, Oculus Rift and computer screen. Further, it presents the comparative analysis of various VR systems and concluded that Head Mounted Display-based VR systems stimulate young pupils' interest in learning about the cultural heritage. Guidi, Russo, Anghelddu, and Zolese (2012) presented the process of data acquisition and 3D modeling to virtually reconstruct lost architectures using the Cham temples located in My Son archaeological area of Vietnam as a subject matter. The aim of the research was to present an extensive 3D documentation of an archaeological site and the reconstruction process. The research primarily focused on reality-based reconstruction utilizing laser scan survey. The researchers believe that the reconstruction path detailed out in this paper may help archaeologists and technical experts in the virtual reconstruction process of lost architecture. Similarly, Guidi, Russo, and Anghelddu (2014) describe a more detailed process of reality-based heritage reconstruction. This research experimented on Vietnam's Cham temples as well. The process involved in the virtual reconstruction of Bishop's cellar, a 13th Century structure at the Island Ivo in Kristianstad was described by Karlsson (2013). This reconstruction is based on the archaeological data found during the excavation between 1938 and 1948. The research primarily focused on the previous works in the area of virtual archaeology and presented a case study on the virtual reconstruction of Bishop's cellar. The author followed a very simple approach in the reconstruction process: 3D modeling using Blender, and walkthrough using

Unity, and argue the main goal of developing the virtual reconstructed model of Bishop's cellar was to be able to present the process of creating a virtual model of lost structures based on the archaeological material. R. M. Levy (2002) virtually reconstructed a temple site in Phimai, Thailand to experiment the reconstruction process and presented the issues faced during the architectural reconstruction process. The primary goal of this research was to discuss the methods for modeling archaeological sites in order to present the limitations of data, data interpretation, hardware, and software and display devices. R. Levy and Dawson (2006) presented an interesting use of the laser scanning based reality modeling for the virtual reconstruction of a Thule Whalebone House. During the late 12th century, whalebones were used by the Thule people to construct the roofs of their winter houses. As very few of such houses remain intact, the author attempted to reconstruct a virtual model of a Thule house in order to teach archaeology to students. Likewise, Micoli, Guidi, Angheluddu, and Russo (2013) suggested a methodology based on 3D laser scan survey and reconstructive modeling in order to increase the knowledge of a historic building and supporting its historical interpretation. For this experiment, the authors worked on virtually reconstructing the Chartreuse of Pavia, a UNESCO World Heritage site. Rizvić (2017) proposed an interactive virtual heritage application with storytelling feature to investigate how users appreciate the form of presentation. For the purpose of this research, the author developed the Taslihan project which is based on the partially lost cultural monument from Sarajevo, Bosnia, and Herzegovina. This study found that the virtual heritage projects become more appreciated by the users when it is designed with digital storytelling feature. Also, it found that increased user immersion is achieved if the storytelling is crafted by a professional writer.

Traditionally, virtual reconstruction of historical sites and buildings has been a popular method to incorporate virtual heritage. However, in the last 20 years, video games have also emerged as

an interactive media that is able to promote VH in a highly appealing way (Bontchev, 2015). Serious games are computer games that allow the collaborative use of the 3D environment that is used for educational purposes in different application domains. The main strengths of serious games are communication, collaboration mechanisms, interactivity, visual expression and entertainment (Anderson et al., 2010). The most important feature of serious games (SG) is its aim of supporting the players to achieve learning targets through interactive and fun experience (Mortara et al., 2014). Heritage learning is one of the application areas of serious games. Games for cultural heritage are intended for appreciation of cultural content (Laamarti, Eid, & Saddik, 2014). The serious games developed in the domain of cultural heritage mostly focus on the cultural learning aspects rather than the virtual reconstruction process as discussed in most of the above-mentioned projects. The research in the area of serious games for heritage learning primarily investigates the users' cultural knowledge acquisition, usability, cultural content, etc. Interestingly, the serious games developed for heritage learning is often based on hypothetical sites or buildings. Hence, it can be observed that serious games in the domain of cultural learning do not always focus on accurate reconstruction of archaeological sites.

Similar to virtual reality-based heritage learning projects, several attempts have been made to teach history using augmented reality technology as well. Moorhouse and Jung (2017), based on focus group experiments, concluded that Augmented Reality is a very powerful tool that must be implemented at cultural sites in order to offer a valuable learning experience. Girbacia, Butnariu, Orman, and Postelnicu (2013); Singh et al. (2015) designed and developed a mobile augmented reality application called CI – Spy that is embedded with several AR-based learning activities that focus on teaching inquiry skills. The researchers used a local historic site namely the Christiansburg Institute or CI as a case study to deliver an on-site Augmented Reality-based

experience along with historical artifacts within the augmented environment to present relevant contextual information. Younes et al. (2017) presented a detailed procedure on the virtual reconstruction of the Roman Theater of Byblos. One of the main focus of this experiment is the historical study, which helped the researchers to hypothesize the original form of the theater. Another important focus of this study is to present the detailed procedures in the development of both a virtual and augmented reality application of the Roman Theater. Jakobsen, Larsen, Nørlem, and Kraus (2017) presented the concern that innovative technologies like augmented reality fail to meet end users' needs in heritage learning, and developed and evaluated an augmented reality application of lost Viking ring fortress of Aggersborg. This experiment evaluates the user experience in the augmented reality system focusing on the usability of the AR system. The research evaluates the experience of two groups of users: children and seniors and found that the application significantly increases user experience for children, while not creating the same for seniors.

It can be observed that the virtual heritage projects generally investigate the efficacy of the developed system in teaching history or simply present the process involved in the virtual reconstruction of the lost heritage sites. To understand the aims of the virtual heritage projects, this study categorizes the projects into three: Product, Process, and People. The virtual heritage projects that aim to investigate the efficacy of the developed virtual heritage system in cultural learning is categorized under 'Product'. Whereas the 'Process' category includes projects that present the procedures and techniques involved in the data acquisition, accurate reconstruction of lost structures, restoration, and virtual reconstruction process. The third category 'People' deals with projects that mainly focus on the end-users' interests, preferences, and perspectives in a virtual heritage environment.

Table 1: Virtual Heritage Projects

VH Project / Game	Research Paper	Category
Pre-Reformation Edinburgh	Abdelmonem (2017)	Product
Jarlshof, Shetland Island	Abdelmonem (2017)	Product
Roman Theater of Byblos	Younes et al. (2017)	Product
Viking ring fortress	Jakobsen et al. (2017)	Product
Taslihan	Rizvić (2017)	Product
St Andrews Cathedral	Fabola and Miller (2016)	Product
CI – Spy	Singh et al. (2015)	Product
Ancient Agora of Athens	Kontogianni and Georgopoulos (2015)	Product
Gates of Horus	Jacobson, Handron, and Holden (2009)	Product
Virtual Priory Undercroft	Wright and Madey (2008)	Product
Roma Nova	Frischer (2008)	Product
Ancient Pompeii	Maïm et al. (2007)	Product
Cham Temples, Vietnam	Guidi et al. (2014)	Process
Cham Temples, Vietnam	Guidi et al. (2012)	Process
Freiria	Rua and Alvito (2011)	Process
Black Church	Girbacia et al. (2013)	Process
Bishop’s Cellar	Karlsson (2013)	Process
Chartreuse of Pavia	Micoli et al. (2013)	Process
Thule Whalebone House	R. Levy and Dawson (2006)	Process
Temple site in Phimai	R. M. Levy (2002)	Process

Reviewing the Problem: Product, Process and People

While reviewing the virtual heritage projects, it can be observed that the VH projects primarily focus on either the Process (virtual reconstruction) or the Product (efficacy of the VH system) but

do not consider the People, i.e. the end-users (Tan & Rahaman, 2009). Much of the effort in VH application is aimed towards developing accurate representations of cultural elements and physical precision of historic architecture style (Yang, Peng, & Sun, 2006). In most of the cases, VH applications are generally reproductions and reconstructions of archaeological sites or historical monuments (Bonini, 2008). Roussou (2008) argue that the virtual reconstruction applications are predominantly developed by researchers and academicians that requires expertise. But, the final product remains within academic and research domain. Such experiments that remain only in the domain of academia and research, involves participants that seek cultural information because they need to or are required to.

Nofal, Reffat, and Vande Moere (2017) argue that archaeological sites and historical monuments are not merely physical structures, but they convey different types of cultural information and values over time. Cultural heritage information types tend to differ from factual or quantitative information (e.g. functions of the building or building date), which are generally not hard to represent, to more tacit qualities and values (e.g. architectural design, cultural values, the symbolic meaning of a structure) that are hard to represent due to their abstract and subjective character. Precisely modeled virtual buildings and landscapes only give a sense of precision, but only human part allows people to engage in VH environments (Mosaker, 2001). According to the pre-survey conducted by Arifin, Martin, Ryan, and Dratama (2018), 65% of the participants did not show interest in learning history, and its due to the reason the method of teaching or delivering the lesson was not attractive. Rahaman and Tan (2010) argue that humans are cultural beings having the cultural and demographic background. Every visitor has their own cultural and demographical background, so each cultural objects communicate a different meaning to each person. An archaeological relic that may be very interesting to one visitor but not for another

visitor. Hence, the VH environment must be designed and developed in such a way that the user wants to go where they will experience the things the world is meant to show (Mosaker, 2001).

Based on the above arguments, one issue that need to be addressed is whether the existing virtual heritage environments consider the users' perspectives, opinions, and interests, and provide sufficient features to enhance the cultural learning, rather than focusing on accurate representation of lost structures or investigating the efficacy of different types of VH systems. In the past, there has been a very little research conducted to understand the factors that are identified from the users' perspective in order to support the cultural learning process.

End-users are casual users who are not experts and seek information due to intrinsic motivation. There is another group of users who seek information because they have to or required to. Those users include experts, researchers, teachers, students, etc. The participants of most of the VH projects that are categorized under 'Product' belong to the second user group. Such VH projects are ideal for a formal education setting where the researchers expect the users to acquire as much cultural information as possible because the efficacy of such projects will be determined by the amount of knowledge the users gain and retain. However, according to Lord (2007), museum learning is informal and voluntary. Lord contends that the evaluation of museum education is not based on mastery of facts or the amount of information the visitors retain, but whether the users take away a new interest towards the subject.

Hence it is imperative to investigate and understand the end users' perspective in a VH environment and identify the factors that could enhance their cultural learning.

Related Work: Understanding End-User’s Interests in VH Environments

Ibrahim et al. (2015) addresses very similar concerns as this research does, and worked on identifying the factors that could support the cultural learning process in VH environments from end-users’ view. While the aims of both the research are quite similar, there are significant other similarities and differences between both the studies as addressed below.

Table 2: Comparison of the relevant project with current research

	Ibrahim et al. (2015)	Current Research
Virtual Heritage Media	Online Heritage Websites containing textural information, Images, virtual environment	Head Mounted Display- based First-person Virtual Reality Environment containing avatars
Virtual Heritage Type	Architectural Heritage	Architectural Heritage
Number of projects presented in the study	5	1
Virtual Reconstruction process	Not involved	Virtual Reconstruction based on materials available in the museum
Materials presented to participants	Only website content	Museum materials and Virtual Reality Environment
Participants	Voluntary knowledge seekers	Voluntary knowledge seekers
Collected data type	Qualitative	Qualitative

Although the above-mentioned study addresses similar concerns and attempts to understand end-users’ perspective using a qualitative research methodology, the work of Ibrahim et al. (2015) is based on online heritage websites. In the current study, we are interested in virtually reconstructing a lost building based on the materials available in the museum, and understand the perspective of end-users (museum visitors) focusing on Head Mounted Display-based first-person virtual heritage environments.

CHAPTER III

METHODOLOGY

The research is aimed at investigating the end users' experience when exploring the virtually reconstructed model to identify the factors contributing towards their cultural learning experience in VH environments. In order to achieve the research objective, a lost historic building has been identified. The building was located in Chappell Hill, Texas.

Chappell Hill was the home of two Methodist institutions of higher education, Soule University, and the Chappell Hill Female College. Soule University was chartered by the State in 1856 and construction of its three-story building began in 1858. The school was closed during the Civil War, and the building was used as a Confederate convalescent hospital. The university reopened after the war and functioned until 1873, when the Methodist Church opened Southwestern University in Georgetown, Texas. Although the school lost its connection to the Methodist Church at that time, it continued to function as Soule College until 1887 when it was finally closed. The building was torn down in 1911. About fifty years ago, the residents of Chappell Hill recognized that the little village still had its quaint 19th century look and feel, but the ravages of time were taking their toll. In order to save the most important structures, they formed the Chappell Hill Historical Society and started acquiring these buildings. The Society currently owns and maintains four historic buildings, and one of them was converted into a museum. Approximately 200 visitors each month visit this museum, where one of the rooms features Soule University.

The research methodology contains two main steps. They are

1. Develop Virtual Reality-based Experiential Model of Soule University
2. Evaluation of user experience using a qualitative research methodology

Development of Virtual Reality-based Experiential Model

To create a virtual reconstruction of a lost structure it is necessary to have textual and archaeological evidence (Fattovich, 2003). Textual evidence includes things that are in the form of written material like administrative records, literary texts, and the archaeological evidence is the physical remains of the past. This evidence is crucially important in the virtual reconstruction process in order to present accurate information about the past (Karlsson, 2013).

In order to develop an accurate 3D model of the Soule University Building, the researcher regularly visited Chappell Hill, Texas and the Historical Society Museum of Chappell Hill as they were an essential part of gathering data, understanding the history and imagining what was in place before the Soule University building was torn down.



Figure 1: Materials available in the Chappell Hill Museum

The information required for the 3D reconstruction work was acquired by an extensive survey of the surveyed photographs, sketches, textual records, and artifacts. Analyzing the textual records in the museum provided us the information about the materials used in the construction of the Soule University Building, number of classrooms located in each floor, other functional spaces inside the building, size, and built-up area of the building. From the textual records, it was identified the university building was a three-story structure, 56' x 80' stone structure of approximately 14,000 square feet. The exterior walls were of two and a half feet thick, while the interior wall thickness and the ceiling height differs from floor to floor. The walls of the first floor were two feet thick, and twelve feet between floor and ceiling. The walls of the second floor were one and a half feet thick, and sixteen feet between floor and ceiling. The walls of the third floor were fifteen inches thick and ten feet between floor and ceiling. A thorough investigation of the building specification released by the Soule University to the contractors and builders in the year 1859 revealed the architectural layout of the building interior, size, style, and a number of doors and windows in each story. Similar to the literature survey, the photos and sketches and artifacts were also extremely useful as they allowed us to visualize and check all the details of the building exterior, especially details relating to the architectural style and texture.

With all the information relevant to building metrics, architectural style, building components, materials and texture duly compiled, the next step in the process of 3D reconstruction is the development of two-dimensional plans for each story of the university building. The purpose of the AutoCAD 2D plans were to import them into the 3D modeling software to develop the 3D Geometry.

Given that it was not possible to discern the exact interior configuration of the building, assumptions were made based on the textual description of the building configuration.

Assumptions that were made to develop the plans were of sizes of the classrooms, location of staircases, riser height and tread depth of stairs, width of the corridor, placement of windows and doors, etc. Based on the assumptions and textual records, floor plans of the building were developed using the software AutoCAD. AutoCAD was chosen because of its availability and flexibility to draft 2D drawings quick and with greater precision, with no extra training was necessary. After the 2D plans were developed, for the initial review of the design, 3D model was developed using the software Archicad.



Figure 2: The Archicad 3D model reviewed in Twinmotion

Archicad is a Building Information Modeling (BIM) software that features readily available building modeling components like walls, doors, windows, stairs, etc. Archicad BIM software was used for the initial review of the building design because of the frequency of changes expected in the design of the building. Using a BIM software allowed us to make frequent changes and review

the model without waster too much time in modeling and modifying the geometry. The 3D model of the building was reviewed in a software called Twinmotion. Twinmotion was chosen as a review tool because of its real-time photorealistic visualization feature. After the review process, the final 3D model for developed using Autodesk Revit.

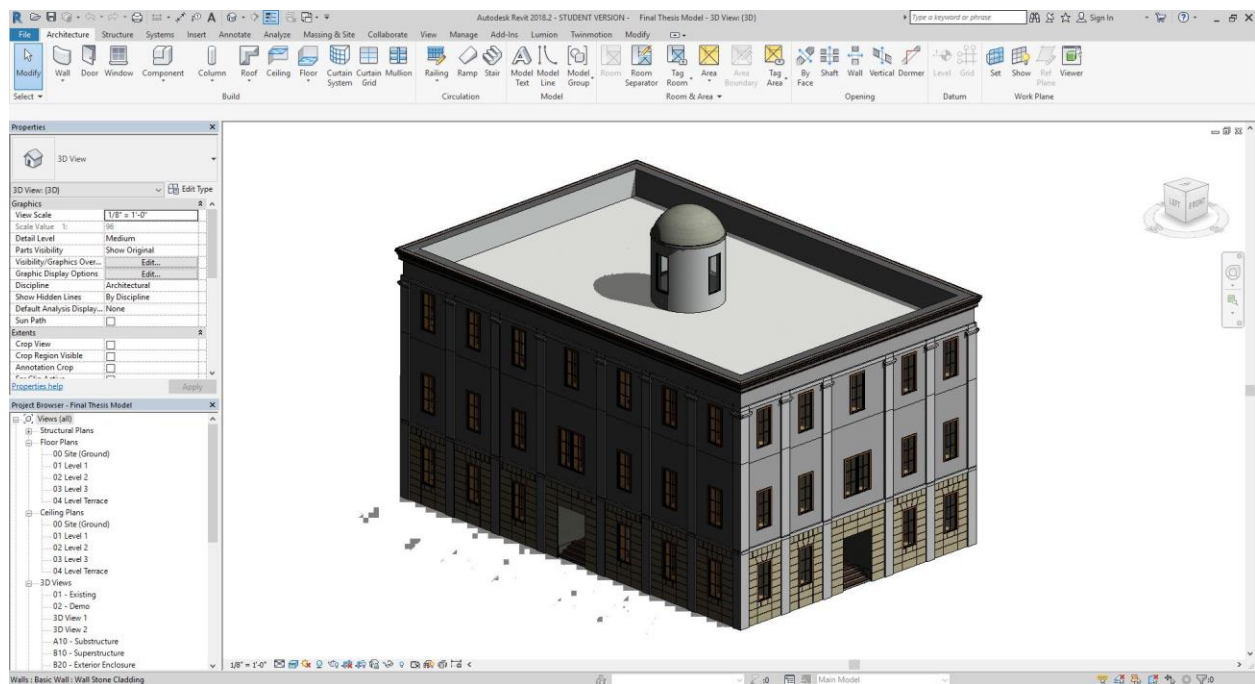


Figure 3: Final 3D Model of Soule University developed in Autodesk Revit

Creating a VR Model: Unity 3D is the software used to develop the Virtual Reality Model. Unity 3D is a robust game engine. Unity 3D provides solutions for powerful rendering and the application has a wide range of in-built tools like scripting, animation, interface design, etc. that allows us to instantly develop a virtual system. Unity 3D has the feature of import 3D models from variety of 3D modeling applications in different formats. Further, the Unity asset store is an online

platform to download 3D assets as required for the projects. Also, Unity 3D has the feature of publishing projects that can be visualized using Head Mounted Displays.

The virtually reconstructed model of Soule University Building in 3Ds Max can be imported and visualized in Unity 3D. The 3D model of the building was exported in FBX format from 3Ds Max. The FBX format is a 3D asset exchange format that allows the seamless and high fidelity geometry exchange between 3D modeling software. A new Unity Project was created, and the FBX file exported from 3Ds Max was copied to the asset folder within the project directory. Once the 3D model is copied, it appears as a 3D asset in Unity. While the Unity scene is loaded with no objects, we created a terrain asset to hold the 3D model of the building. The 3D Model of the building is then dragged and dropped into the scene and placed over the terrain.

In order to publish the 3D scene in Unity into a Virtual Reality model, there is a requirement of placing “First-person camera” asset provided by the Head Mounted Display manufacturer. For our project, we decided to use the Head Mounted Display (HMD) called Oculus Rift. As we mentioned above, the “First-person Camera” assets downloaded from the Oculus VR website and imported into the scene.

Virtual avatars were developed using Adobe Fuse and rigged used Mixamo. The character models were exported in .FBX format and imported into Unity.



Figure 4: VR Model of Soule University featuring Virtual Avatars

Evaluation of End-User Experience

The main ideology behind this research is to investigate the end-users' experience of the Virtual Reality-based experiential model tool in order to identify what the end-users prefer to see in the VR setup and how the VR setup can be improved in order to keep them engaged in such virtual environment. For the purpose of this research, it is crucial to investigate human interactions with the developed Virtual Reality-based learning tool for the lost building and collect feedback about their experience. To evaluate the developed learning method, qualitative research methodology is used. The qualitative research method that will be used for this research is phenomenological analysis. The phenomenological analysis involves understanding individual's perspectives as one experience and understand an emotion, program, relationship, event, etc. The feedback from the participant would be used to identify end-users interests and the pros and the cons of the VR based

learning tool. Creswell (1998) recommends 5 to 25 participants as a typical sample size for a phenomenological study. Interviews were conducted with 13 museum visitors as part of this study.

The interviews were designed in a way to gain an understanding of the individual's perception towards using VR-based Experiential Learning tool. The interviews were designed to be very flexible and informal by asking open-ended questions to the participants, thus allowing them to express their thoughts on the developed learning method for lost buildings. During the data analysis part, the researcher identified common themes from the interview transcripts. The theme of interest for this research is the pros and cons of the VR based learning tool and recommendations & improvements the end users would like to have in a VR based learning of lost historic buildings.

CHAPTER IV

DATA COLLECTION

Phenomenological study was conducted to evaluate the participant's experience using the developed Virtual reality-based experiential model of Soule University. The interviews were audio recorded to make sure the responses were documented without any interruptions. The audio recordings were later transcribed and the data was analyzed to understand the users' perception about the presented VR setup to learn about the Soule University.

The phenomenological study requires a minimum of five participants to be interviewed (Hycner, 1985). Considering the importance of interviewing the end users in order to achieve the objectives of this study, the experiment was conducted at the Chappell Hill Historical Society Museum and the museum visitors were recruited to participate in this study. In total, thirteen individuals participate in this study, and the experiment was conducted individually for each participant. After recruitment, the participants were first asked to explore the materials available in the museum in order to gain familiarity about the traditional way of learning about a lost building. This step is crucial in order to make sure the participants understand how and what information are presented in museums to learn about the past.

After exploring the materials available in the museum, the participant was taken to the auditorium hall in the museum where the virtual reality tool was set up. The participant was given a brief presentation about the devices and how to navigate using the gamepad. Then the participant was asked to wear the earphone and the Head Mounted Display (HMD). After receiving consent from the participant, the researcher initiated the VR application and asked the participant to start

exploring the building while providing required instructions. The researcher answered any questions the participant had while exploring the virtual environment.

The participant was asked to take their own time to experience and explore the virtual environment. Once the participant completed their tour, the researcher interviewed the participant and recorded the responses.



Figure 5: Chappell Hill Museum visitors exploring VR Model of Soule University

In order to protect the privacy of the participants, their identities were not revealed and were noted as Interviewee 1, 2, 3, .13. Since the results of this study is based on the feedback delivered by the thirteen participants, their credibility is a crucial factor for receiving reliable results. Hence,

the individuals working on museum education who assisted us throughout this project were not included in this study.

The following questions were asked by the researcher to the museum visitors during the interview sessions:

- Describe about your overall experience in using this Virtual Reality set up to learn about a lost historic building?
- If you would like to share your experience in three different words how would you describe?
- You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing or to be added in this way of learning using virtual model compared to the traditional method of learning about Soule University?
- When I explained to you about this research project about Virtual tour of Soule University, what came up in your mind? What expectations you had? Like what you thought that you are going to see inside this?
- We have tried to use virtual characters to share information about the Soule University. How helpful was it to learn about the lost building?
- What do you think about the information shared by President Mood?
- What more information you would like to see or hear while exploring a lost building using such virtual reality set up? You heard some information from the virtual avatar, what more you'd like to have here to learn about the Soule University?
- When we talk about virtual tour of lost buildings, each person has different expectations. What is important to you in that virtual tour? What would you like to see inside such virtual models?

- If you would like to give me one compelling reason why you prefer this virtual reality based learning compared to traditional method of learning what would you give?
- If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?
- If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?
- What improvements would you suggest to improve this virtual reality set up as a learning tool to educate the public about the lost Soule University?

The interview questions helped to know the end users' (museum visitors) feedback about their experience and identify their opinions, perspectives, expectations, preferences, needs, and suggestions. Appendix A contains the transcripts of the thirteen interviews conducted to evaluate the user's experience in the developed first-person virtual heritage environment. The following chapter discusses the results of the phenomenological study.

Data Analysis

Phenomenological research methodology was adopted to analyze the gathered data. The analysis methodology of the interview data was based on the guidelines demonstrated by Hycner

(1985). The following seven phases of qualitative research were adopted for analyzing the data collected.

Phase 1: Transcription of audio. This is an obvious and important part of the qualitative analysis. Data collected from the audio-recorded interviews were transcribed. This includes the literal statements and significant non-verbal communications. During this phase of analysis, the researcher, read each transcript multiple times to gain familiarity with the interview data and to get an overview of possible categorization of collected information.

Phase 2: Phenomenological reduction. This is a process performed while listening to the audio recordings and reading the interview transcripts. The researcher approached the collected data, that is, the audio recordings and the transcripts, with an openness in thinking to different meanings emerged. This allows to enter the world of the museum visitors who were interviewed in order to understand the meaning of what the individual is saying, instead of what the researcher expects from the participant to speak.

Phase 3: Listening to the interview for a sense of the whole. During this phase, the researcher listened to the entire recordings multiple times as well as reading the transcripts multiple times. This gave a context for the development of very distinct units of meaning and themes.

Phase 4: Delineating units of general meaning. In this phase, the researcher stayed very close to the literal data. During this phase, the researcher performed a meticulous process of going through each word, phrase, sentence, and paragraphs in the transcript in order to derive the end-user's perspective. This phase resulted in deriving the units of general meaning. Unit of general meaning can be defined as those words or sentences that express a unique meaning.

Phase 5: Delineating units of meaning correspondence to the research questions. In this phase, the researcher addressed the research questions to the units of general meaning in order to ascertain whether the research participant has given response relevant to the research questions.

Phase 6: Grouping units of relevant meaning. In this phase, the researcher attempted to categorize the units of relevant meaning. In this research study, the categories were derived from the units of general meaning that seems to have common theme or essence that unites various units of relevant meaning. Based on the research questions, the units of general meaning were organized in two broad categories: Environment Design and Presentation Design.

Phase 7: Identifying themes from clusters of meaning. At this stage, the researcher interrogated all clusters meaning to ascertain whether there is one or more central themes that communicate the nature of these clusters. The units of meaning in the ‘Environment’ category was organized into five themes, and the ones in the ‘Presentation’ category was organized into two themes.

CHAPTER V

RESULTS AND DISCUSSION

This section of the report presents the main findings in correspondence to the research questions. Findings presented in this research are entirely based on the feedback, comments, perspectives, and concerns raised by the participants during the experiment. The findings provided deep understanding about useful design elements for first-person virtual heritage environments and characteristics of historical and cultural information that are important for heritage learning in a first-person VH environment. The results are presented based on the categories and themes as identified in the Phase 6 and 7 during the data analysis.

Environment Design

Table 3 summarizes the themes and corresponding elements regarding the design features related to the virtual heritage environments.

Inclusion of Tangible Cultural & Historical Information: During the experiment, while exploring the VH model of Soule University, most of the participants expected or wanted to visualize the tangible cultural information. Some of the tangible cultural information participants showed extreme interests were architectural aspects, artefacts, archaeological relics, surrounding context, occupied spaces (with furniture), costumes of people, etc. The following are some of the comments made by the participants:

- *“...I'd like to have some more architecture details, the costumes of the avatar that were there were kind of compelling, that would attract the users. And the surround area of the building. Because you up and look out of the window, and I know the focus of the project*

is on the university, but when you go up to the window in this beautifully rendered building, and I see this bland, infinity horizon....” (Participant 5).

- *“...In the museum, I see some scientific instruments, so if there are such instruments in this model, it would be good...” (Participant 6).*
- *“...The pieces that I am interested in is may be little difficult to put in. If often pay attention to things like hinges, the mechanical parts that made the building. It is the little artwork and the little craft pieces. Which is going to be little harder to deal with. It is certainly going to be much more intricate piece for the architecture and archaeology to determine what was appropriate. So just the layout of the building, the architecture, and then the fittings like door knobs, hinges, etc. That’s what I am interested about...” (Participant 7)*

Functionally active environment: Most of the users wanted to visualize the functionally active spaces in order to learn and understand the population and specific activities that took place inside the lost Soule University. The following are some of the comments made by the participants:

- *“...there were no students. I wanted to know how many students attended this university... I thought I am going to see people moving. I expected more activities and stuffs... when I explored the classrooms all looked same. I’d like to know whether it is a freshmen classroom or sophomore classroom...” (Participant 2).*
- *“... I am interested in building and its use. What the people did in the building. Probably I would like to know about the historical things I heard about...” (Participant 6).*

Participatory and Interactive environment: Another interesting feature recommended by few participants is that they wanted to participate in the discussions with the virtual avatars, classroom activities and get recognized by the characters in the virtual environment. Some users mentioned

that while exploring the building, their presence within the building want to be recognized so that they can interact with the virtual characters.

Table 3: Themes and Elements for Environment Design

Research Component	Themes	Key elements
Environment Design	Inclusion of tangible cultural information	<ul style="list-style-type: none"> • Architectural Details • Artifacts • Archaeological relics • Surrounding context • People’s costumes • Furniture / Fixtures
	Functionally active environment	<ul style="list-style-type: none"> • Activities / Business • Population
	Participatory and Interactive environment	<ul style="list-style-type: none"> • Interact with avatars • Participate in activities
	Navigation	<ul style="list-style-type: none"> • Guided tour • Self-navigation • Instruction to control navigation • Signage and labels • Teleport
	Realism	<ul style="list-style-type: none"> • First-person VR • Historically accurate • Graphics

Navigation: Many participants raised concerns regarding the navigation inside the building. Some of the participants preferred to have a guided tour, while others preferred to explore the building on their own. Hence the system must be designed to have options for both self-tour and guided tour so that the users can choose their preferred way. Other important concern raised by the participants was regarding the instructions to control the navigation tool (gamepad). Even though the participants were tutored how to use the gamepad, many participants wanted to have specific

instructions on the screen regarding the navigation. Some participants requested to have signage and labels, and some would like to teleport to different floors and spaces without climbing the stairs or walking back through the same path they came through. Few participants recommended having shortcut buttons on the screen to click and move to other floors and spaces.

The following are some of the comments made by the participants:

- *“...It would be helpful if the rooms have some kind of captions or sign on the rooms one can get an idea what they are looking at... I expect that the actual building would have a signage that tell you to go up through the stairs to the second floor auditorium. Probably there should be a signage that this is an Auditorium”* (Participant 6).
- *“...It would be nice to have some short cuts for back down to the first floor instead of going down through the stairs...”* (Participant 7).

Realism: Almost every participant mentioned that they like the first-person virtual reality based learning of the lost building because of the reason they were able to visualize the lost building and explore in and around at a human scale. Also, they appreciated the quality of the graphics that made them experience the cultural presence. The following are some of the comments made by the participants:

- *“...Realism, the reality. You are there. Experiencing along with the time... You know you can look around just than reading or looking at the pictures. You can put yourself in the building...”* (Participant 1).
- *“...I think this kind of realistic presentation shows how the life was like taking you back to actual time when this happened. This technique puts you back in time and let you experience what actually happened. I can see the realism...There is realism. Seeing the characters move and talk. I don't think any other method can do this. You are placing the*

viewer back in time, actually, relive what happened. I don't think other method of teaching would be able to do that...." (Participant 4).

- *"...From the traditional method, I did learn a lot but it really didn't describe about the overall structure of the building like where the classrooms were, etc...."* (Participant 8).

Presentation Design

Table 4 summarizes the themes and key elements that describes the perspectives of participants in terms of presenting the information.

Characteristics of information: Based on the results, the end-users' showed interests in learning about a wide range of things. The researcher has categorized that information into three namely cultural, historical and contextual information. The type of cultural information the participants showed interest is the lifestyle of people, business activities of people, the regional accent of people, etc. Likewise, the historical information recommended by the participants includes historical significance of the lost building, stories about notable people who lived in the town, historical events associated with the lost building till it got torn down, etc. In addition to the cultural and historical information associated with the building itself, most of the participants wanted to learn more about the surrounding context, especially the Chappell Hill and the surrounding towns.

The following are some of the comments made by the participants:

- *"... there was a time when after the President Mood left, and the school carried on. I don't know whether you can add more information about what happened after President Mood left. I think the records show that it was probably operating until 1887, and by then President Mood moved to Georgetown. If you could bring things right after 1887, little more about the history of Soule University after Mood left..."* (Participant 4).

- “...To understand the historical backdrop, not just with the school itself, but adding information about the context. May be adding information about the civil war. This was based on President’s viewpoint. You may add some more character or narrator and tell why the school was important and why location was important...” (Participant 8).

Dissemination of information: In this study, avatars played a key role in the dissemination of information to the participants. Every participant provided positive feedback on learning from the avatar that represented late President Mood. It was observed that the participants enjoyed walking towards the avatar and listening to the speech delivered by the avatar. In fact, the participants wanted each avatar inside the building to deliver some kind of information to the visitors, instead of standing idle or acting like talking among themselves. Most of the participants mentioned that they gained some new knowledge about the lost building while listening to the avatar compared to learning from the museum materials. Based on this observation, the researcher strongly recommends the inclusion of avatars to present the cultural and historical information. Another format of information recommended by the participants was using the human voice to present the information through avatar instead of using computer-generated voice. Some of the participants wanted to have historical notes, written records, and photographs presented on the wall. Many participants recommended using captions to describe a particular space, and some mentioned about presenting blueprints of the building to understand the building layout. The following are some of the comments made by the participants:

- “...I love first person stories. I think it would be interesting if you have stories from some of the students...” (Participant 3).

- “...I expect that the actual building would have a signage that tell you to go up through the stairs to the second floor auditorium. Probably there should be a signage that this is an Auditorium....” (Participant 6).

Table 4: Themes and Elements for Presentation Design

Research Component	Themes	Key elements
Presentation Design	Characteristics of information	<ul style="list-style-type: none"> • Cultural • Historical • Contextual
	Dissemination of information	<ul style="list-style-type: none"> • Avatar-based • Human voice • Captions • Photographs • Letters / Notes / blue prints • Virtual Representation of artifacts

Factors Contributing Towards End-User’s Learning Experience

The results presented in the above sections demonstrate four significant types of conclusion. First, the findings signify the importance of including different types of information for heritage learning. Second, the users have preferences regarding how they want to access the information. Third, the users’ experience of interacting and participating in the VH environment play an important role in having them engaged while learning about the past. Fourth, the navigation features that aid the users to explore in and around the building

Based on these observations, this research proposes four contributing factors that need to be incorporated while developing first-person VH-based learning environments. The four factors are information design, information format, experience design, and navigation system. Table 5 summarizes these four factors.

The first factor, *information design*, signify the types of information need to be presented in the virtual heritage environments. This factor is further categorized into three elements: Cultural information, historical information and contextual information. Cultural element includes both tangible and intangible features like architectural features, artifacts, lifestyle of people, business activities, etc. Historical information includes historical significance of the lost building, historical events, stories about notable people, etc. Contextual information refers to the surrounding context.

Table 5: Factors contributing towards cultural learning in VH environments

Factors	Elements
Information Design	<ul style="list-style-type: none"> • Cultural (Tangible and Intangible) • Historical • Contextual
Information Format	<ul style="list-style-type: none"> • Avatar-based • Wall Display (Photographs, notes, letters, blueprints) • Human voice • Captions • Virtual Representation of artifacts / relics
Experience Design	<ul style="list-style-type: none"> • Functionally active • Participatory and Interactive • Realism
Navigation System	<ul style="list-style-type: none"> • Guided tour • Self-navigation • Instruction to control navigation • Signage and labels • Teleport • Minimap

The second factor, *information format*, demonstrates the way the information is delivered and communicated to the museum visitors. Some of the elements of information delivery identified in through this study are avatar-based storytelling, inclusion of human voice in storytelling, virtual

representation of tangible features like archeological relics and artifacts, and displaying information on the walls.

The third factor, *experience design*, deals with the features that enhance the user experience within the virtual environment and keeps it interactive and participatory. Some of the key elements of this factor are realism, functionally active environment, getting recognized by the avatars, participating in the discussion, etc.

The fourth factor, *navigation system*, deals with the elements that aids the users to explore the virtual heritage environment seamlessly without getting lost or missing crucial information. Some of the elements features in this factor are self-navigation, guided tour, signage for spaces, on-screen instructions for using the gamepad, etc. Although the navigation system does not help directly to the users' cultural learning in virtual heritage environment, this factor is crucial to encourage the museum visitors to explore the VH environment and aids in accessing the cultural information.

As demonstrated in the literature section of this report, the target users of this study are those casual visitors who possess intrinsic motivation to learn about the past. This type of users have the option of ignoring any information presented, or to discontinue whenever they want. Such participants provide attention if the information they receive and the environment they explore continues to be very interesting, engaging and interactive. Hence, this research proposes that while developing a virtual reality-based heritage learning environment for casual users, it is important to create environment and present information that keeps them engaged and adds value to their cultural learning. The ultimate aim is to gain users' attention by providing interactive learning environment, information design and delivery and navigation system.

There have been attempts made in the past to understand the end-users' requirements in VH environments. Most of those studies are based on expert reviews. Once such study was conducted

by Abubakar, Jahnkassim, and Mahmud (2013). In this study, the researchers proposed five factors from the perspective of the experts. The five factors are content, experience, setting, support, and interface. Comparing these factors with the findings of the current research reveals that there are few elements identified in this study matches with the items demonstrated based on expert reviews. They are described in Table 6. It can be observed that most of the common elements are related to the content of the VH environments, and more specifically, tangible features. Much of the elements identified in this current study based on end-users' perspective were not identified in the study based on expert reviews. This observation is in line with the argument made by Roussou (2008) that the virtual reconstruction applications are predominantly developed by researchers and academicians and remains only in the domain of academia and research that do not involve end users. Also, it justifies the need for understanding the end users' interests and preferences in virtual heritage environments.

Table 6: Common elements between expert review and end user perspective

	Abubakar et al. (2013)	This research
Content	Space and building functions Architectural features Replication of ruins Significance of the building Scale of the structure	Architectural aspects Building functions Virtual representation of artifacts Significance of building Virtual representation of the building
Experience	Walkthrough ability of virtual reality	First-person VR, self-navigation

This research acknowledges that some of the elements suggested by the contributing elements are already addressed in different range of research contexts (VR domain, heritage learning domain, medium of virtual heritage). However, attempt to investigate the combination of

information design, information delivery, experience design, and navigation system in the context of virtual reality-based heritage environment projects with the intention to enhance the cultural learning of casual users in first-person virtual environments has never been made.

CHAPTER VI

CONCLUSION AND FUTURE WORK

This research investigates the end-users' perspectives in a first-person virtual heritage environment to identify the elements and factors that promote their cultural learning experience. The findings propose that a combination of information design, information delivery, experience design, and navigation system needs to be considered while developing VH applications. Creating a virtual heritage environment incorporating the factors and elements identified in this research could enhance the cultural learning experience of end-users. These elements and factors could serve as design guidelines for development of virtual heritage environments focused on lost buildings.

As identified by Walsh, Clough, and Foster (2016), there are eight different categories of users that use digital heritage environments. The domain expertise and the technical expertise of the users presented in those categories varies as Low, Medium and High. The motivation to seek historic knowledge differs as well. According to Mosaker (2001), users' perspective in virtual heritage environment differs from person to person based on their subject knowledge and technical expertise. Hence, future work could focus on understanding the user requirements and interests for each category of users identified by Walsh et al. (2016). This could help to develop and evaluate virtual heritage systems from the perspective of different groups of human actors.

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APPENDIX A

INTERVIEW 1

Interviewer: Describe about your previous experience in using Virtual Reality Head Mounted Displays?

Interviewee 1: I have never used something like this before.

Interviewer: How was this experience in using a Virtual Reality device to learn about a lost building?

Interviewee 1: What I really think about this is I could really enjoy, it is really realistic.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee 1: Realistic, Everything was there even listening to the gentleman talk, to look up and actually see the way building was made

Interviewee 1: When I described about this experiment about Virtual tour of Soule University, what came up in your mind? What you thought you are going to see?

Interviewee 1: I didn't think it is going to be as realistic as it was

Interviewer: What information did you expect when you were exploring the Soule University using this Virtual Reality setup? You explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this virtual tour compared to the traditional method of learning about Soule University?

Interviewee 1: I don't think you missed any information. You got the introduction about the university, you have people standing around, talking, you got a close up of classrooms, chapel, etc.

Interviewer: What you think those characters present in the virtual model. Did that help you to understand about the cultural style?

Interviewee 1: I think it was the style of that period.

Interviewer: What do you think about the amount of information delivered by the virtual character about the Soule University? Were you able to follow what he talked?

Interviewee 1: I was. I understood everything he said.

Interviewer: What improvements would you suggest for this virtual reality model in order to educate the people about Soule University?

Interviewee 1: Since this is a university I'd like to see how the actual classroom setting was.

Interviewer: You mean students sitting in the classroom and professors teaching.

Interviewee 1: Yes, I'd like to see that.

Interviewer: When we say virtual exploration of lost buildings, what it means to you? What is important to you?

Interviewee 1: To be able to see the building of that time period, the clothing,

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the

advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee 1: I would choose to go with the virtual version. Because you are there. You know you can look around just than reading or looking at the pictures. You can put yourself in the building.

Interviewer: Did this set up meet your expectations to learn about Soule University?

Interviewee 1: Actually it exceeded my expectations.

Interviewer: What difficulties you faced from the time you started exploring the virtual model till the end of your tour?

Interviewee 1: I am not so used to these technologies, so had troubles in using these tools (gamepad).

Interviewer: I understand you had some troubles in navigating. How it would have been if I was totally controlling the game pad and navigating you throughout the tour?

Interviewee 1: It wouldn't have been as interesting

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee 1: Realism, the reality. You are there. Experiencing along with the time

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee 1: I can't really say that. I think if I get little better in navigation.

Interviewer: The museum contains the artifacts, real photographs, etc. but this model doesn't have any real things, it's all virtual.

Interviewee 1: I was actually inside the building. That's why I like this.

INTERVIEW 2

Interviewer: Describe about your previous experience in using Virtual Reality Head Mounted Displays?

Interviewee: This is the first time I am using

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: I liked it

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: Great. It was amazing. I was thrilled.

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: There was no students. I wanted to know how many students attended this university.

Interviewer: That's a good observation

Interviewee: I'd like to see how many students were there since this was a university

Interviewer: What feature about this virtual tour you really liked?

Interviewee: The classrooms, the floors, I was able to understand the size of the classrooms.

Interviewer: When I explained to you about this experiment about Virtual tour of Soule University, what came up in your mind? What expectations you had? Like what you thought that you are going to see inside this?

Interviewee: I thought I am going to see people moving. I expected more activities and stuffs. That's what I thought I am going to see.

Interviewer: We have tried to use virtual characters to share information about the Soule University. How helpful it was to learn about the lost building?

Interviewee: I was shocked. In never knew about this university in my life.

Interviewer: We have used the virtual characters of people lived in that period to provided information about the lost building. What do you think about this kind of presentation to educate people?

Interviewee: I really liked it

Interviewer: If you would like to give me one reason why you prefer this virtual reality based learning compared to traditional method of learning what would you give?

Interviewee: I like because I see people explaining things. And in this way you can see the building itself, I can see the windows, light fixtures, etc. so I like this better.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: I like this compared to that

Interviewer: The materials in this museum has more information about the lost Soule University, like the artifacts, photographs, written notes, etc. Those kind of information are missing in the virtual model. But you feel this virtual reality model is better than the traditional learning. Why do you think so?

Interviewee: This looks more real. I can travel through, go to different classrooms. I like the reality of this thing.

Interviewer: What information you would like to see or hear more in this virtual model. You heard something from the virtual character, he was talking about the building. What more you'd like to have in such virtual tour?

Interviewee: When I explored the classrooms all looked same. I'd like to know whether it is a freshmen classroom, or sophomore classroom that kind of information.

Interviewer: When we talk about virtual tour of lost buildings, what is important to you in that virtual tour? What would you like to see inside such tour?

Interviewee: Lifestyle of people. Navigating this one.

Interviewer: I understand you had difficulties in navigating.

Interviewee: I just don't want to use this one. I want someone else to control this.

Interviewer: Oh, you want someone else to navigate using this for you.

Interviewee: Yeah. I don't want to navigate at all.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: This one. Because I was like I am walking into the building. Was like I'm inside the building. This seems to be more real.

INTERVIEW 3

Interviewer: Describe about your previous experience in using Virtual Reality Head Mounted Displays?

Interviewee: I have never used.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: I like it. I liked the guy talking about the building. It was very cool.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: Speech was very good, great to hear as first person. Second experience was you need to have lot of time to explore the room, I was kind of getting motion sickness. But overall I thought it was very cool.

Interviewer: You explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this virtual tour compared to the traditional method of learning about Soule University?

Interviewee: I didn't remember everything I saw in the museum. I liked the stories. I think it is very good to listen to stories as first person instead of trying to read and retain it.

Interviewer: What feature of this virtual reality tour you liked the most?

Interviewee: I liked the feature of standing in the room and listening to the guy.

Interviewer: What more information you would like to see or hear while exploring a lost building using such virtual reality set up? You heard some information from the virtual avatar, what more you'd like to have here to learn about the Soule University?

Interviewee: I love first person stories. I think it would be interesting if you have stories from some of the students.

Interviewer: When we talk about virtual tour of lost buildings, what is important to you in that virtual tour? What would you like to see inside such tour?

Interviewee: I would like to see more about people's lives. The stories about people's lives and their experiences.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I think if you have the rooms totally completed, like the books, things hanging in the wall, and furnished out it would be more interesting.

Interviewer: So you prefer this way of learning about a lost building?

Interviewee: Yes, I do. I like first person.

Interviewer: What more improvements you would like to see in this kind of virtual tour of lost buildings?

Interviewee: I'd like to learn using this (gamepad) before starting the tour. I think if you have more first person stories from the students you know their experiences. That would be great.

INTERVIEW 4

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: This is the first time I have done this. This is really quite amazing

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: Are these people also going to speak? I'd would like to have these people speak something.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: I'd like to have these people speaking. They are speaking but I don't hear what they speaking.

Interviewer: What information you would like to see or hear more in this virtual model. You heard something from the virtual character, he was talking about the building. What more you'd like to have in such virtual tour?

Interviewee: Can you add some students? Some of the students walking around, sitting down in the chairs. I'd like to see some students.

Interviewer: What do you think about the information shared by President Mood? Were you able to follow what he said?

Interviewee: Yeah, I thought it was very good.

Interviewer: What do you think about the amount of information shared by him? Is it too much, or too less?

Interviewee: I think he covered it pretty well. From the time he first came to school till the time they decided to move this school to Georgetown. I think he covered that pretty well. That was not too much or not too little.

Interviewer: When we talk about virtual tour of lost buildings, each person has different expectations. What is important to you in that virtual tour? What would you like to see inside such virtual models?

Interviewee: This part here was obviously the time of President Mood. I think this is after the war. There was a time when after the President Mood left, and the school carried on. I don't know whether you can add that information about what happened after President Mood left. I think the records show that it was probably operating until 1887, and by then President Mood moved to Georgetown. If you could bring things right after 1887, little more about the history of Soule University after Mood left.

Interviewer: If you would like to give me one compelling reason why you prefer this virtual reality based learning compared to traditional method of learning what would you give?

Interviewee: I think this kind of realistic presentation how the life was like taking you back to actual time when this happened. This technique puts you back in time and let you experience what actually happened. I can see the realism.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: I think I am going to repeat things a little bit. There is realism. Seeing the characters move and talk. I don't think any other method can do this. You are placing the viewer back in

time, actually, re-live what happened. I don't think other method of teaching would be able to do that.

Interviewer: For any specific reasons do you think the traditional way of teaching about lost building is better than using such digital models?

Interviewee: I think both methods are complementary to each other. And certain things like the realism of characters moving. This adds to it. It takes you away from the exhibit room, and lets you see what it is like inside the Soule University.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I think President Mood's remarks were covered very well. What his hopes for the University were. Probably he had in mind that Chappell Hill was not going to be the best location. The important point was that. After President Mood was brought to Chappell Hill he seemed to realize that because of the threat of the yellow fever probably Chappell Hill was not going to be the location of the school. He had plans to move it to some other place. President Mood's remarks were pretty comprehensive. So I think I would prefer this way.

Interviewer: What improvements would you suggest to improve this virtual reality set up as a learning tool to educate the public about the lost Soule University?

Interviewee: I think it would be great if you could add about some events happened during that time period. President Mood was not the only popular person. There were many other famous people. Where these people go was a big news. Like “Mr. X visited this house” gets featured in the newspaper. It would be great if the characters talk about such news.

INTERVIEW 5

Interviewer: Describe about your previous experience in using Virtual Reality Head Mounted Displays?

Interviewee: Very limited use of Head Mounted Displays. But I have played lot of games using one or multiple monitors on PC.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: It is really nice. If you move fast, it gets little glitchy. But for the most of the part it was smooth. I don't know how much coding it would take, when you are walking by outside the building, I'd like to see the shadow of myself. You are not going to see yourself, but would like to see the virtual icon react to the environment. Adding a secondary push using the analog to open the door would be great. Because when the door opens away from you is not a problem, but when it opens towards you while approaching it is problematic. I mean, overall, it is nice. The only thing it didn't have that I would like to see is the access to the roof. The stairs was smooth and it was nice.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: Immersive. Interesting. It was neat. It was really interesting, I wanted to see what's in this corner, what's in this classroom, whether these chairs move when I walk through them. So, it was exciting.

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: Without going into the micro details. Because for instance, the actual picture of the wall, it would be difficult to render in the 3D environment. Other than that I don't think one is better than the other. They can be done to harmonize each other. Like the old fashion way has text on the wall and some artifacts. In this, you have icon of somebody speaking. If you have somebody reading that part instead of voicing the text, you can have proper pronunciation of some of the names and words as supposed to be. The character pronounced the word Soule in three different ways, and none of them were correct it is pronounced. I'd like to have somebody reading the text would harmonize with the traditional exhibit. Because it will have the actual pronunciation, accent of the region so you can put it in the context. While the old way could fix with it by close captioning it. That word they said is that's what it is. I don't think one is any better than other. They can work on to harmonize each other.

Interviewer: What do you think about the amount of information delivered by the virtual character about the Soule University? Were you able to follow what he talked?

Interviewee: It was a good amount. My concern is that the speech would have been from his personal anecdotes. Were those personal anecdotes from that man's writing? You could say "See References". Somebody who comes from historian's perspective doesn't feel like "Well this man

is just making up to make it look interactive”. You can have this additional information that is true quotes. It was a nice size sound bite, but it was lot like personal interjection. But as a historian one would like to have citations.

Interviewer: When we talk about virtual tour of lost buildings, each person has different expectations. What is important to you in that virtual tour? What would you like to see inside such virtual models?

Interviewee: I mean to have it more immersive, I’d like to have some more architecture details, the costumes of the avatar that were there were kind of compelling, that would attract the users. And the surround area of the building. Because you up and look out of the window, and I know the focus of the project is on the university, but when you go up to the window in this beautifully rendered building, and I see this bland, infinity horizon.

Interviewer: What improvements would you suggest to improve this virtual reality set up as a learning tool to educate the public about the lost Soule University?

Interviewee: I think the high points someone should learn about this building is, of course, its use. The materials. The rendering is nice, but it is generic. The history put forward by the President was nice. The information was very nice and tight. But there are more things after the civil war. It was more about founding the Soule University. Because of its history, it used to be Boys and Girls College and it got separated. So I would like to see more history.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: I think that for getting the younger audience to be drawn into the museum setting things have got to be put in an environment they are used to be. I see that you need to be able to communicate with somebody in their language. And the kids these days that what they know.

You present the information in the format that they are more comfortable with and compelling. I think for the younger crowds this would be awesome. In conjunction with the older one, you can use the older one as a springboard into this for the older crowd. You can say “Hey here is the old picture of it and everything, do you want to take a walk through that building?” I think it is purely to get the younger crowd which is a target market for growing museums.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: If I had to pick a reason, the traditional one has the real artifacts. So you have the touch tone with the reality. So for the old traditional way of showing things gives you the touch tone in reality. These were real, living, breathing, coughing people.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: If I had to choose just one, I'd would probably go with digital one. Purely with the flexibility of use of space. And that the variance of the format that you could have somebody sitting here and take them around like “By the way let's just take a jog till the street and here we are at the Chappell Hill female's college. Oh, there is the dorm next door”. In the virtual space, you can have that done on budget. And museums struggle with their budget, even big ones. This

would be space friendly and time friendly. I think space wise, time wise and money wise, digital model is the best.

INTERVIEW 6

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: No, this is the first time.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: I like the VR concept a lot.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: Well it was unique. I think it could be a good learning tool.

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: It would be helpful if the rooms have some kind of captions or sign on the rooms one can get an idea what they are looking at.

Interviewer: When I explained to you about this experiment about Virtual tour of Soule University, what came up in your mind? What expectations you had? Like what you thought that you are going to see inside this?

Interviewee: I thought I'd would be able to walk around and see the rooms. I did not think I'll be able to see the characters inside the building. In the classroom, I'd see some furniture, blackboard something like that. I kind of assumed that building would be empty. I was surprised

to see the people. That's a nicely added touch. I expect that the actual building would have a signage that tell you to go up through the stairs to the second floor auditorium. Probably there should be a signage that 'This is an Auditorium'. If the classrooms were of different grade level or if they were dedicated to different subjects, then I'd like to expect to see a signage of that. In the museum, I see some scientific instruments, so if there are such instruments in this model, it would be good.

Interviewer: When we say virtual exploration of lost buildings, what it means to you? What is important to you?

Interviewee: I am interested in building and its use. What the people did in the building. Probably I would like to know about the historical things I heard about. I fell virtual model is really interesting other than the aspect that you don't see real items. Huge advantage of virtual tour is you don't have to go to where the museum is. It is portable. That's a huge advantage. This is particularly cool. Because the building doesn't exist any longer and you don't see it.

Interviewer: What do you think about the amount of information delivered by the virtual character about the Soule University? Were you able to follow what he talked?

Interviewee: In the beginning, I thought it was fine. It could have been a guided tour. If you were with the goggles you don't see the controls, so a guided tour would be better.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: Well this is self-guided. When you allow the user to explore by themselves you wouldn't know whether the user accessed all the information you want them to. But if it is a guided tour you can for the information presented to the user. I see that as an advantage.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: If it is a guided tour you don't get the advantage of stop and look at stuffs you are interested in.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I prefer wandering around the museum. Let me explain that with an example. Let's say I am going to a museum with my wife. She and I have different interests. We go looking at certain things and hand around in different area looking at something different. We connect at some point, and but we can stay with our own interests. So I see that as an advantage. Other thing is in the real museum, you get to see the real artifacts.

INTERVIEW 7

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: I have used this before for playing games.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: It was very good. It would have been great if there was an indicator about the usage of controller.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: Realistic, layout was nice, neat

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: The presentation in the museum gave a background about the building but it was difficult to understand what the building looked like. So this gives a good idea about what the building looks like and the uses. The guy in the building covered some material but missed some as well. May be some student in there could be used to share stories. It can be from the students or it can be like you can go and read from the desks. I am glad you had desks that made me understand the scale. It is hard to say what the size of the room is if there is no human in it. The piece of information missing was the narration about what the spaces are.

Interviewer: What do you think about the amount of information delivered by the virtual character about the Soule University? Were you able to follow what he talked?

Interviewee: It was easy to follow.

Interviewer: When I explained to you about this experiment about Virtual tour of Soule University, what came up in your mind? What expectations you had? Like what you thought that you are going to see inside this?

Interviewee: From my experience with other visualization and 3D models, this actually came in. I really like the idea of the building itself applied to build a game space.

Interviewer: When we say virtual exploration of lost buildings, what it means to you? What is important to you?

Interviewee: The pieces that I am interested in is may be little difficult to put in. If often pay attention to things like hinges, the mechanical parts that made the building. It is the little artwork and the little craft pieces. Which is going to be little harder to deal with. It is certainly going to be much more intricate piece for the architecture and archaeology to determine what was appropriate. So just the layout of the building, the architecture, and then the fittings like door knobs, hinges, etc. That's what I am interested about.

Interviewer: What feature you did not like about learning about a lost building using this kind of VR setup? And why?

Interviewee: I think it is more like dealing with the interface at this point. It would be nice to have some short cuts for back down to the first floor instead of going down through the stairs.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: In VR it actually helps you to put in human terms.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: Sometimes seeing the real artifacts makes better connection with the past.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is

better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I would probably lean towards the VR version. Because it gives me potentially the opportunity to visit a building that I would never get a chance to visit.

Interviewer: Would you like to give me any suggestions to improve this VR setup as a learning tool?

Interviewee: Probably if you could use one of the avatars as a tour guide would help to know about the functions of the building. Having that guidance would make it lot easier for lot of people.

INTERVIEW 8

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: I have used a game console before. But have not used a Head Set.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: It was pretty good. This looks like an accurate layout of what the school was like. I enjoyed the background information the character provided. I think it mispronounced few words. It would be better to have a voice recorded.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: It was easy, informative, it gave me a very good mental model.

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: To understand the historical backdrop, not just with the school itself, but adding information about the context. May be adding information about the civil war. This was based on President's viewpoint. You may add some more character or narrator and tell why the school was important and why location was important.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: From the traditional method I did learn a lot but it really didn't describe about the overall structure of the building like where the classrooms were, etc.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: Artifacts that pertain to this school. I don't know whether you would be able to do that. Like the mason setting up the corner stone. I don't know whether that kind of information can be communicated easily through this method. I'd like to see the history leading up to the building like someone setting the corner stone. I think that additional information might be difficult to be incorporated in this set up.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the

traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: For the overall history, I would probably go with the traditional method. For the structure itself, I would go with this method.

INTERVIEW 9

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: No.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: It was very interesting. I like the fact that it is interactive. I think it would really appeal to younger people. I liked the visual aspects. I liked the fact that it looks like you can go into it and can be a part of it.

Interviewer: What more information you would like to have in this VR set up to learn about the Soule University?

Interviewee: I find the female character not historically accurate. I would have them saying something about businesses, life, etc. I would say use them to talk about life in Chappell Hill around the time. Brenham was very small compared to Chappell Hill. People moved to Brenham because of the yellow fever. Brenham grew because of that. I think if you could bring that aspect in it, it would be inclusive. Have them explain the life in the Chappell Hill outside of the school.

Interviewer: When we say virtual exploration of lost buildings, what it means to you? What is important to you?

Interviewee: I think the more detail of the building, and history is important. It has to be historically accurate.

Interviewer: What do you think about the amount of information delivered by the virtual character about the Soule University? Was that too large or too little?

Interviewee: I think it depends upon the audiences. I thought it was great, I did not know few things that were presented. You can have them in the second floor and say something different.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: I have never used this so I can't really answer that. But I can tell from my son's perspective. I think libraries have to embrace this kind of technologies. If a 30 year old walks in the museum, if he has the combination of these it would be quite amazing.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: There is nothing I don't like about this. Only thing I did not like was the lady's makeup that did not go with that period.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I think most people are visual learners. So this is appealing. I think anybody can look at a picture and say it is wonderful, but if walk in the picture it is a whole different world. I think it is the future.

INTERVIEW 10

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: No, I haven't.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: It was really fun. I got to see how the building really looked like.

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: Interesting, informative and fun.

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: This is not lacking anything. This is good. The speech given by the gentleman was long. It could have been two people. The thing about the yellow fever was also interesting.

Interviewer: What do you think about the amount of information delivered by the virtual character about the Soule University? Was that too large or too little?

Interviewee: I don't think it was too much.

Interviewer: What more information you'd like to see in this model?

Interviewee: I am interested in if there were any letters from students how the classes were like. I didn't hear what they taught. What classes they taught.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: I would probably go with this. Because it is not dry. It is alive.

Interviewer: When we say virtual exploration of lost buildings, what it means to you? What is important to you?

Interviewee: The architectural design, the layout of the building.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: It made me dizzy.

Interviewer: What improvements you would suggest to improve this as an education tool?

Interviewee: Having students at their desks. What would be on the walls? What did they decorate with?

INTERVIEW 11

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: No, this is the first time I am using this.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: It was pretty good. I understand there was computer generated voice. There were few words, he did not pronounce well. Overall it was pretty good. There was little lapse in the lips movement, but I did like the way the eyes blinked. I noticed that so I did not feel like I was talking to a machine.

Interviewer: How was your learning experience? Did you get to learn anything about the Soule University?

Interviewee: Yeah, I did not realize that this was the predecessor to Southwestern. I did not know that guy was the leader of the institution. It was interesting he was in need of USD 150 to repair the roof. I am sure back in that time that was a lot of money.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason. Is there any reason why you didn't like this method of learning?

Interviewee: I am more of a computer guy anyway. Honestly, I think may be to younger generation it might be appealing. Probably for my wife it may not be appealing. She likes to read everything. Maybe going into little bit more into architecture details, the building, might be student at the desk, teachers at the desk. If you want to take it to a little bit further, may be you can have a teacher teach a lesson so that you are like you are walking into the class and listen to the teacher. May be have a student talk about the life then.

Interviewer: What more information you would like to have in this virtual model?

Interviewee: Was there any reason why it was built the way it was? I am not much of a history guy, but I'd like to learn about the life. I love this architecture.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: The potential for the interaction. Hearing the story was good. I have been to some museum where they will have little video of some kind. You did a very good on developing the computer generated voice. But I'd like to hear from people.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: I don't find any reasons for not recommending this setup. The only I did not like was the graphics things while listening to the character. May be you want to work on the more natural speech.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I would choose this. Because I am able to walk inside the building. You really get to see the reproduced colors. If you actually recreate the furniture layout this is perfect. This would be a really good learning tool. May be you can throw in some of the artifacts.

Interviewer: Is there any suggestions you would like to give to improve this as a learning tool?

Interviewee: If there are any photographs of places around it, if you could bring that in that would be great.

INTERVIEW 12

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: No, this is the first time I am using this.

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: That was fun

Interviewer: If you would like to share your experience in three different words how would you describe?

Interviewee: It was interesting. It was very good. I liked it.

Interviewer: When we say virtual exploration of lost buildings, what it means to you? What is important to you?

Interviewee: I think I would be more on the people aspects. If it is possible to go and sit down in the classroom and participating and seeing what is going on in the classroom.

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: I would love to see the actual classrooms and more of the human aspects. This is just a structure without life in it. What kind of décor was in the building?

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: I only thing I had issues with while listening to the speech was I was not able to take notes. Because you cannot write while having that (HMD) same time. But for someone who is not going to take notes, that is not a problem.

Interviewer: What improvement would you suggest to improve this as a learning tool?

Interviewee: I guess you want have more of what was in there. What each room had. Or you can something like blueprints to show what was in there.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model, you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I guess I'll go with the traditional style. It is more visual. It is more real.

INTERVIEW 13

Interviewer: Have you ever had experience in using Virtual Reality Head Mounted Displays?

Interviewee: No

Interviewer: How was your overall experience in using this Virtual Reality set up learn about a lost building?

Interviewee: It was kind of cool. It was obviously very well researched.

Interviewer: You went and explored the museum and learned about the Soule University using the traditional way, now you walked through the virtual model of Soule University. What kind of information you felt is missing in this way of learning using virtual model compared to the traditional method of learning about Soule University?

Interviewee: This is a great aspect. This is a good concept. You have more of a feeling of in the building. However, it feels like a bare bones type of thing, whereas the exhibits give you more of human aspect of it.

Interviewer: When we say virtual exploration of lost buildings, what it means to you? What is important to you?

Interviewee: Historically speaking I like the personal stories. The Architecture is really nice. Yes, I look at buildings and I look at the architecture. I really liked the shadow and sun light. It was good to interact with the gentleman.

Interviewer: What do you think about the amount of information delivered by the virtual character about the Soule University? Was that too large or too little?

Interviewee: History wise it is good. If you want to go further I would suggest adding students or something in the classrooms with some fun stories. I find that really weird stuffs keep people interested. It is true.

Interviewer: If I ask you to give me one reason that you like this virtual reality based learning compared to the traditional way of learning what would you say?

Interviewee: They always say if you want to learn a language you should get immersed into it. If you want to learn a building you should get immersed into it. You will get more of a feeling like what the building was like instead of from stagnant pictures which is true. I saw there were three floors in the picture, I was like Ok three floors. Here I know there were classrooms, auditorium, and more classrooms. Also, the classrooms on the first floor were of same size but the ones in the third floor were of different sizes. So it makes to feel like there were specific class upstairs and general classes downstairs. It gives you a better feel.

Interviewer: If I ask you to give me one reason for not willing to use this set up, what would you say? Like you don't want to use this set up for some particular reason.

Interviewee: In the traditional way, you get the aspects of artifacts. Here you are in the virtual world. You could fall off the stairs and don't get hurt yourself. Whereas in the real world exhibits you do see the tangible objects in the building. So both are actually kind of good.

Interviewer: If I give you two options to learn about a lost building like Soule University. First is the traditional way of learning as you see in this museum, and the second is the virtual model of Soule University. Which one would you choose to learn about the lost building? None of them is better than the other. Each one has some advantages and some disadvantages. Like in the traditional setting you are able to watch the real artifacts, photographs. In the Virtual Model you can explore inside the building. If I ask you to choose only one, considering seriously the advantages and disadvantages of both the method, which one would you choose to learn about a lost building?

Interviewee: I would probably go with the virtual way. It is more immersive. You get more of the feel in the building. The stagnant old exhibit again you would be like there are three floors, but what was where. Here you know there were classrooms. You get a better feel for it

Interviewer: Would you like to give me any suggestions to improve this as an education tool?

Interviewee: The voice. It would be nice to have another character speaking.