ANALYZING VISITORS' DISCOURSE, ATTITUDES, PERCEPTIONS, AND KNOWLEDGE ACQUISITION IN AN ART MUSEUM TOUR AFTER USING A 3D VIRTUAL ENVIRONMENT

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The main purpose of this mixed methods research was to explore and analyze visitors' overall experience while they attended a museum exhibition, and examine how this experience was affected by previously using a virtual 3dimensional representation of the museum itself. The research measured knowledge acquisition in a virtual museum, and compared this knowledge acquired between a virtual museum versus a real one, employing a series of questionnaires, unobtrusive observations, surveys, personal and group interviews related to the exhibition and the artist. A group of twenty-seven undergraduate students in their first semester at the College of Architecture and Design of the Autonomous University of the State of Mexico participated in the research, and were divided in two groups, one of which used a 3D virtual representation previous to the museum visit.

Results show that participants who experienced the virtual museum concurred that using it was a positive experience that prepared them to go to the real museum because they knew already what they were going to find. Most of the participants who experienced the virtual museum exhibited an increased activity during their museum visit, either agreeing, being more participative,

concurring and showing acceptance, asking questions, or even giving their opinion and analysis, disagreeing with the guide and showing passive rejection. Also participants from this group showed an increase on their correct answers to the knowledge acquisition questionnaires, going from 27% answers responded correctly in the pre-test, to 67% of correct answers after the virtual museum usage. The research attempted to show that experiencing a virtual museum can be similar to the experience in physical museum visits, not only engaging participants to go to the museum, but sometimes even offering a more functional way to deliver content. Results of this research evidence that using a virtual museum creates a positive impact in users before, during, and after the museum visit, and that it can be a good alternative, not only for educational, but for promotional and recreational and purposes

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CHAPTER 1

INTRODUCTION

Millions of people visit museums every year. According to a survey (Blanton, 2009) released in 2009 by the American Association of Museums, just in the United States museums received over 850 million visits, including 55 million student visits during the 2007-08 school years. This contributed to the American economy in $20.7 billion.

The concept of what a museum is has changed over the years; before museums started noticing their own importance in the education process and started offering learning programs and tours, they were seen as huge storing places focused only on the care, preservation, and exhibition of objects (Willumson, 2007). Just as museums have taken on major educational roles in many countries through programs and exhibitions intended to benefit various segments of the population, they have also become active preservers of vanishing cultures, not just passive collectors of cultural artifacts (Hein & Alexander, 1998).

Every year, teachers and educators organize field visits to museums as a side activity of their coursework. Families, tourists, and groups of friends visit museums around the world (Hooper-Greenhill, 1994). It is well known that in museums people can find different kinds of information, and sometimes they can find learning opportunities (Hein & Alexander, 1998).

In recent years, museums have realized the importance of the Internet to deliver content. Museums around the world are offering their information online to further expand their outreach (Urban, Marty, & Twidale, 2007). Kazmer and Haythornhwaite (2005) stated “As these users reach for their keyboards, they enter environments that involve more, and deliver more, than rote instruction” (p. 1). Users enter online communities, learning through collaborative peer-to-peer interaction with other users distributed across states, countries and time zones. This is achieved using different media, such as online forums, chat clients, web pages, wikis, blogs, podcasts, video chats, and more recently 2-dimensional and 3-dimensional online environments.

These online museums vary in presentation with some offering their content displayed via traditional web page, where visitors can click on the images of the works of art and read the description of the pieces, like the Museum of Modern Art in New York (2011). Others offer three dimensional representations of their exhibition rooms like the Google Art Project (2011) or the Valentino Virtual Museum (2011). Some online museums offer an almost realistic view of the genuine museums and some others can be considered multi-user virtual

environments (MUVEs), which enable multiple simultaneous participants to access virtual contexts, to interact with digital artifacts, and to represent themselves through "avatars" to communicate with other participants and with computer-based agents (Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004).

Purpose of the Study

Museums are places for personal learning, and may be called a free-choice experience (Falk & Dierking, 2000). A study made by Nevius (1982) suggested that free-choice experiences might be shaped by culture and social participation. Museums have become places for collection, preservation, documentation, research, and education using the information and artifacts they display (Hein, 1998). Millions of people have access to that information but unfortunately there are millions that for many reasons including money, lack of time, or distance cannot access these materials (Alcalde & Rueda, 2007). The Internet is an option for people to access museums that may otherwise never have that experience (Higgings, 2009). The issue of distance as an important factor for not attending museums was first addressed at the International Seminar on the Role of Museums in Education, sponsored by the United Nations Educational Scientific and Cultural Organization (UNESCO) in 1954 (McCann, 1955). The report of the seminar mentioned that mobile museums could be the best device of the future for carrying the original material to outlying regions beyond the immediate influence of a museum. Such mobile museums would

have to be accompanied by a “carefully planned educational programme” but only as a preparation for the eventual visit to the museum itself (p. 18).

The main purpose of this mixed methods study was to explore and analyze visitors’ overall experience while they attended a museum exhibition, and examine how this experience was affected by previously using a virtual 3dimensional representation of the museum itself. The research explored the use of existing 3D virtual environment technologies by bringing a selected permanent museum exhibit displayed at the University Museum Leopoldo Flores into online 3D experiences, measured knowledge acquisition in a virtual museum, and compared this knowledge acquired between the virtual museum versus a real one, employing a series of questionnaires, unobtrusive observations, surveys, personal and group interviews related to the exhibition and the artist.

Relevance and Value of the Study

The information contained in museums is of great cultural and historical importance, and their educational role is long standing and well established as a concept (Hooper-Greenhill, 2000). However, not all the people have access to that information because of several reasons, thus they are missing that source of knowledge (Boffey, 2011).

The study’s intention was to advocate for the use of self guided virtual tours so more and more people can have access to the information contained in the museums having fewer barriers such as time, money, or distance required to

travel to these sites. As the research results attested, there is an indication that a self-guided virtual tour can provide users with knowledge outcomes and attitudes that affect the museum experience in a positive way, if is used previous to the museum visit. The purpose of this research was not to try to find a substitute for museum visitations, but to offer access to people who cannot attend those spaces the possibility to access at anytime and anywhere the valuable and unique information museums hold within their walls.

The primary assessment mechanism for this research thesis was embodied in the questions being examined and project milestones. These included: a) usage of a previous built virtual replica of the selected exhibit, b) data collection and analysis, c) student collaboration and scholarly interactions, and d) presentation of results.

Methods

This research involved mixed methods to triangulate data that tried to "confirm, cross-validated and corroborate findings" (Creswell et al., 2003). This triangulation consisted of direct observations during the visit to the museum and while using the virtual environment that were videotaped and then transcribed, analyzed and coded into similar topics; individual and group interviews using open ended questions; and quantitative analysis of the participants' knowledge acquisition as a result of their experience using the virtual environment and their

experience visiting the museum, using a questionnaire that included technology usage and basic demographics (see Appendix A for the instruments).

The following question provided research problem that defined the research but three more questions arose and were explored during its course:

In what ways does a pre-visualization of a virtual museum affect the museum experience?

Sub-questions:

1. In what ways visitors discourse is affected by previously experiencing a self-guided virtual tour of the same exhibition?
2. Can users of a self-guided virtual tour show gains in knowledge acquisition?
3. Can visitors who use a self-guided virtual tour and then attend the real museum tour show gains on knowledge acquisition, vs. those visitors experiencing only a museum tour?

Assumptions and Limitations of the Study

The design of this research study was shaped by different personal and professional assumptions. It was assumed that participants would be enthusiastic about the idea of taking part in a museum research project, and that all of them would complete the research process in time, with honesty, and without skipping any procedures. It was also assumed that the theoretical framework and methodology, presented in Chapters 2 and 3, were an accurate representation of

the process being studied. This could be perceived both as an assumption and as a limitation.

It was also assumed that during the course of the study, I was going to have access to all the installations and equipment required to conduct this investigation, which would allow the research process to be finished on time.

Another assumption and limitation was the time management needed for the participants to complete the surveys, to navigate through the virtual environment, and to attend the museum tour. This could have affected the outcomes of the study if participants and/or other unknown causes had modified the timeframe.

The data collection was conducted in Spanish language with the participation of Mexican undergraduate students, and some meanings, traditions or expressions related to the participants' culture were lost in translation to English when presenting the results of the research. I am a native of Mexico and I am familiar with the particular regional variation of the language so no specific problems for translating the questions were presented (Lopez, Figueroa, Connor & Maliski, 2008). However, when translating back the answers, especially the ones of the semi-structured interviews, unfortunately some expressions were lost in translation since there was not an exact word or phrase in English for them. The researcher translated these expressions into similar expressions used in English, avoiding the meaning to be completely lost.

Another limitation was the location and timeframe chosen to develop the study. Data collection was performed in Mexico limiting the opportunity to re-interview participants face to face with follow up questions.

An additional limitation of the study was the lack of literature both concerning discourse analysis and knowledge acquisition in virtual museum settings. While several publications about visitors' discourse in museums are available (Hein, 1998; Allen, 2002; Rowe, 2004; Grek, 2005; Johnstone, 2008) and many more discuss museums and knowledge (Young, 1993; Rennie & Johnson 1994; Hooper-Greenhill, 1999; DeSantis & Housen 1999), there are few studies focused on virtual environments and self guided virtual tours.

Summary

In this chapter, a brief introduction to museum education and virtual museums was presented. The problem statement, research question and sub-questions, and the purpose and relevance of the study were introduced. Assumptions and limitations of the study such as translations, time management and access to technology were addressed.

Chapter 2, Literature Review presents related research and sets the theoretical and conceptual context. Investigations in museum education, virtual museums, critical discourse analysis, and methodology for mixed methods will be introduced.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND THEORY

This chapter addresses definitions and previous work in visualization, introduces the theory of situated cognition and its application in museum education, presents an overview of several research studies related to critical discourse analysis in museums online and on site, and analyzes museum education and development of research in virtual museums. It also introduces the instructional design of the virtual museum used in this research, and discusses the pilot study findings that lead to the development of this investigation.

Visualization and Computers

Immersive virtual reality is defined as the technology that gives the user the psychophysical experience of being surrounded by a computer-generated environment, (Dam et al., 2000) and has the potential to be a useful instrument for visualization. This technology is being used for walkthroughs of buildings and other structures, virtual prototyping, medical applications, and entertainment. Scientists use simulation and visualization as an alternate means of observation

and it is “a powerful technique because it exploits the dominance of the human visual channel” (p. 27).

Recent advances in information technology are allowing people to browse information in any order, rather than being constrained by the linear ordering of information in printed books, and computer microworlds are becoming more prevalent in educational programs. Therefore there has been much excitement about the potential of these visualizations for improving education and training (Hegarty, 2004); however, little research has been conducted that might assist in using visuals and sound in an effective manner (Lai, 2000).

Chanlin (1999) examined the effectiveness of integrating still graphics and animated graphics in different learning contents, and their effectiveness to promote learning. One hundred thirty-five college students were randomly assigned into different treatments and given the same computer-assisted lesson. Three groups of students were generated: the first one had textual information to present the content, the second group attended the lesson which had text and still graphics, and the third group attended the lesson which featured text and animated graphics. Pre- and post-tests were provided to all the students to measure learning outcomes. At the end of the experiment, Chanlin concluded that animated graphics improved students’ learning, and were more effective for promoting a deeper level of visual elaboration.

In recent years the evolution in instructional technology has allowed developers to design instructional material that incorporates varied visualizations.

Diagrams and images can now be animated; concepts or phenomena invisible to human eyes can now be shown (Lin & Chen, 2007), therefore visualization properly designed has been found to be an important asset in facilitating student achievements, but its use alone does not always optimize achievement of the more complex types of learning (Wilson & Dwyer, 2001).

Anglin, Vaez and Cunningham (2004) suggested that progress has been achieved in visualization research, but there is still not enough research defining the effectiveness of different types of visualization in helping to acquire, integrate and generate knowledge. However, they concluded that static visual illustrations can facilitate the acquisition of knowledge when they are presented with text materials, but research on the effects of animated visuals is still very limited.

Computers can serve as mediators in the process of rapid assimilation of information (Robertson, Card & Mackinlay, 1993), and computer visualizations attempt to present abstractions of information or objects using color, lightning, shadows, transparencies and motion. According to Huber and Healey (1995) visualization converts information to images that can be used to explore, discover, and analyze. One effective way to build visualizations is to construct mappings based on guidelines from human perception, and these properties can be used to represent information to viewers allowing them to perform high-level analysis tasks.

Several projects have been using virtual visualization in order to train and educate users, and is use is not new; however many of these systems never

have been released to the wider public and have only used for academic purposes (Anderson et al., 2010).

Healey and Enns (2011) stated that a fundamental goal of visualization is to produce images that support visual analysis, exploration, and discovery; and declared that the way people see details in an image can impact viewer's efficiency and effectiveness, thus it is important to choose visual features that will draw the focus of attention to areas in a visualization that contain important data.

The discipline of visualization was born with the rapid development of scientific computing and the use of computer graphics, and it can offer the possibility to enhance teaching and learning (Hansen & Johnson, 2005).

Virtual Environments for Learning

Virtual reality (VR) sometimes called virtual environments (VE) has drawn a lot of attention during the past two decades, and its application in education, science, work, and entertainment areas has substantially increased (Mazuryk & Gervautz, 1996). Virtual environments can be defined as real-time interactive graphics with 3-dimensional models, that when combined with a display technology, can give the user immersion in the model world and direct manipulation (Bishod, Bricken & Brooks, 1992).

Gigante (1993) defined virtual reality as "The illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on a three-dimensional, stereoscopic head-tracker displays, hand/body

tracking and binaural sound. VR is an immersive, multi-sensory experience" (p. 15). When talking about VR there are two important terms that must be mentioned: telepresence which is defined as a specific kind of virtual reality that simulates a real but remote environment (Steuer, 1992), and cyberspace that offers an environment that consists of many participants with the ability to affect and influence each other (Morningstar & Randall, 2003).

Macedonia and Zyda (1997) argued that VEs present users with different "views" (p. 52), which are windows into the VE from a person's or processes' perspective. These "views' can be synchronous and asynchronous. Synchronous VEs are networked virtual environments in which all parties are in perfect synchronization, such that actions made by one participant are felt or seen by all other participants as they occur. Asynchronous VEs are those that do not require the simultaneous participation of all parties (Hiltz & Wellman, 1997).

According to Mazurik and Gervautz (1996) there are different levels of immersion in VR systems. In a virtual environment system, a computer generates sensory impressions which are interpreted by the human senses. The type and the quality of these impressions determine the level of immersion and the feeling of presence in virtual reality. VR became part of many disciplines of human activities as a medium that allows easier perception of data. Therefore the education purposes seemed to be the most natural ones (Loeffer, 1995). In 1999 several members of the World Wide Web Instructional Committee (WWWIC) published an article in the *Journal of Network and Computer Applications* (Slator

et al., 1999). This document stated that virtual environments for education must be designed to capitalize on the affordances provided by VEs. These included: Control virtual time and collapse virtual distance; created shared spaces that are physical or practical impossibilities; implement shared agents and artifacts according to specific pedagogical goals; and support multi-user collaborations and competitive play. Some other characteristics for VEs for education, according to the authors, could include role-based experiences, goal-oriented tasks, learn by doing activities, immersive and spatially oriented atmospheres, exploratory design, game-like projects, and unintrusive tutoring.

Dillenbourg, Schneider and Synteta (2002) defined virtual learning environments (VLEs) as social information spaces where educational interactions occur in the environment, turning spaces into places. Students are not only viewers but also actors, they co-construct the virtual space. VLE's are not restricted to distance education; they also enrich classroom activities and integrate heterogeneous technologies and multiple pedagogical approaches.

As Hargis argued, (2008) there are many educational institutions that have experienced a relatively new potential virtual learning environment called Second Life (SL), which is a virtual land that includes four types of regions: mainland, private region, homestead, and openspace. According to the Second Life web site (Second Life, 2011), there are over 151 educational institutions that have online presence through SL.

Holmberg and Huvila (2008) created a virtual classroom in Second Life which resembled a real-world classroom so that it would feel as familiar as possible. The lectures that took place in the environment were part of a course for continued education for library personnel in different locations on the west coast of Finland. 30 students were asked about their views and opinions on Second Life as learning environment. The web-based survey included 33 questions on a 5-point Likert scale as well as three open-ended questions and some background questions. Conclusions expressed that, according to students, Second Life should not replace face-to-face education, but it could serve as an excellent addition to other more traditional methods and platforms used in education. Students also stated that lectures held in SL were much more “fun” than using other methods.

Carr (2008) defined virtual worlds as computer-based environments which include online games such as World of Warcraft as well as social worlds such as SL. The author stated that there are significant differences between massively multiplayer online role playing games (MMORPGs) and social worlds such as SL, “but educators are interested in the two for similar reasons, including their capacity to immerse and motivate learners, and the potential to alter a user’s relationship to technology” (p. 13).

Online learning environments (OLE) most commonly named E-learning can be defined as learning and teaching online through network technologies (Zhang et al., 2004), enabling a potentially new type of learning community which

provides a space for group discussion as well as access to other students for socializing and communication (Stacey & Rice, 2002). Many researchers have explored the use of virtual environments for learning in projects such as ScienceSpace (Salzman, Dede & Loftin, 1996), Quest Atlantis (Barab, et al. 2001), Civilization III (Squire, 2005), River City (Ketelhut, 2007), Chalkouse (Jones & Warren, 2008), and EcoMUVE (Metcalf, et al., 2010).

Situated Cognition

The theory of situated cognition focuses on the relationship between the individual, the social group, and the context where learning occurs, and it has evolved to include the design of technology or computer based instruction (Altalib, 2002). This theory also states that knowledge is situated and it is affected by the activity, context, and culture. From a situated perspective, it becomes impossible to separate the learner, the curriculum, and the context in which learning occurs (Barab, 2000). This theory was first exposed in 1989 by Brown, Collins and Duguid in the article “Situated Cognition and the Culture of Learning” (Brown, Collins & Duguid, 1989) after observing several effective learning situations in various topics such as math, or literacy where social negotiation was occurring. The authors argued that activity, concept and culture are interrelated and no one can be totally understood without the other two. In recent years, virtual environments have provided with a powerful and acceptable vehicle for the critical characteristic of the traditional apprenticeship to be located

in the classroom environment (Herrington & Oliver, 1991). Mclellan (1991) contended that “while knowledge must be learned in context, that context can be the actual work setting, a highly realistic or ‘virtual’ surrogate of the actual work environment; or an anchoring context such as a video or multimedia program” (p. 27). Cognitive studies have revealed how people learn from failures, and how they relate words and meaning when reading, how problem solvers relate goals to plans, and how decision makers sort through ambiguous, uncertain data (Clancey, 1997).

Wilson and Madsen (1999) discussed two areas of research that are typically associated with situated cognition: anthropology studies where researchers are interested in the cultural construction of meaning in combination with critical theory, Vygotsky’s socioculturalism (Vygotsky, 1978), and Piagetian individualism (Piaget, 1950); and cognitive studies where researchers are interested in cognition at individual and social levels and argue that situated cognition has strong links to artificial intelligence, linguistics, and psychology.

Wilson and Madsen indicated that situated cognition seems to be “the placement of individual cognition within the larger physical and social context of interactions and culturally constructed tools and meanings. Finally, Wenger (1998) resumed the principles of situated cognition theory in 4 constructs: we are social entities; knowledge is a matter of competence performing valued enterprises; knowing is formed when pursuing these enterprises; and learning produces meaning.

Situated Cognition in Museums

Hopper-Greenhill (1999) discussed that understanding processes of interpretation is the core of the education in museum, and this process is shaped by prior knowledge, attitudes and beliefs, and the interrelation between the subject, the object and the setting. According to the author, learning in museums is most effective if it is provoked through enjoyment, reflection and analysis using different alternatives inside and outside the museum, such as exhibitions, workshops and publications.

Semper (1990) stated that experiences in museums motivate children and adults to become more inquisitive, and they encourage the development of curiosity, but argued that research on learning in museums is hard to do because of the episodic nature of the interaction, the divergent backgrounds of the visitors, the free-form nature of the museum visit, and the character of the experiences that are being offered in these places (p. 51). Semper indicated that the learning experience in the museum often occurs within a social context. People come alone or with other people, and they interact with other visitors creating situated meaning throughout and after the museum visit.

Roschelle (1995) declared that museum experiences cannot eliminate prior knowledge, and that museums can provide the visitor with learning experiences using challenging settings that will allow interaction, contemplation, and inquiry. Museums need to provide a high quality experience that engages prior knowledge with knowledge that is being acquired during the museum visit.

Museums must be able to encourage curiosity and exploration, support constructivism and situated learning processes, and develop a personal, cultural, and community identity.

DeSantis and Housen (1999) indicated that for learning to occur, an individual does something, experiences and thinks about the results of the action, and decides what these results mean to her/him. They argued that the construction of understanding is always an organized process of assimilation of information, and accommodation of existing strategies. During the 70s and the 80s Housen studied visitors to museum galleries and noticed patterns or behavior between visitors' thinking and language and then developed the aesthetic development interview (ADI) and the visual thinking strategies (VTS) theory of aesthetic development based in observations of over 4,000 individuals. Housen showed that in addition to developing visual thinking, VTS promotes creative and critical thinking skills through the discussion of visual images. Analyzing these images and using questions such as "What do you see?" and "What else do you see?", individuals are able to externalize their thoughts and find meaning in imagery which involves a set of skills, from simple identification, to complex interpretation (Yenawine, 1997). The theory of visual thinking strategies is still used in museums across America and dozens of schools throughout the country and Europe.

Rennie and Johnston (1994) indicated that learning in museums is personal, contextualized and take time. This learning experience requires

engagement and some mental, physical or social activity, and this experience not necessarily can be seen; rather, learning is observable in an individual's actions: what that person does and says. Falk and Dierking (1992) contended that there are three contexts that influence learning in museums, the personal –visitor's own background with his or her previous experiences-, the social context – visitor's interaction with other people, and the physical context, which refers to the physical aspects of the museum visit, including the architectural features, exhibition layout, and so on. Finally, they argued that learning in museums takes time because visitors need to reflect and assimilate new ways of understanding, thinking, and acting (as cited in Rennie & Johnston, 1994).

Assessment in a Situated Learning Environment

Herrington and Oliver (1991) argued that situated cognition has made a significant impact on educational thinking, and has given researchers the task to identify critical aspects of situated learning and to translate them into teaching methods for learning environments. The authors argued that these environments must provide authentic content, authentic activities, expert performance, and multiple roles and perspectives. They also must allow collaboration, reflection, articulation, and scaffolding. Young (1993) declared that a situated learning environment provides for integrated assessment of learning within the tasks, and noted that "assessment can no longer be viewed as an add-on to an instructional design or simply as separate stages in a linear process of pre-test, instruction,

posttest; rather assessment must become an integrated, ongoing, and seamless part of the learning environment" (p. 48).

McLellan (1993) pointed out that assessment of situated learning can take the form of a number of evaluation measures which do not include formal tests, and can include portfolios, summary statistics of learners' paths through multimedia programs, diagnosis, and reflection and self assessment. Hooper-Greenhill (1994) argued that evaluation in museums is the systematic collection of data and information about the characteristics, activities, and outcomes of an exhibition, and this evaluation is driven by the need for information for specific action in the short term to aid in long-term planning of new exhibitions and/or programmes, The methods for evaluation are changing constantly to reflect improved understanding of the nature of museum and gallery communication and visitor motivation and learning. Hooper-Greenhill also mentioned that evaluation in museums has started to focus in the learning outcomes of educational activities and events, as well as perceptions and attitudes of museum visitors; however the traditional methods do not offer ways of discovering answers to these questions. The author concluded that hopefully 'soft' sciences such as sociology, ethnography and anthropology are bringing new answers by studying people as individuals in their own surroundings rather than as anonymous subjects in laboratories. These field-based methods stress observation rather than analysis, and work towards qualitative rather than quantitative data. Documentation, in-depth interviews, and descriptions result in narrative accounts

where the responses of interviewees are often quoted producing deep descriptions of practice.

Museum Education and Visitors

In 1954, the International Seminar on the Role of Museums in Education was held in Athens, Greece to address the role of museums in education (McCann, 1955). During this seminar, several issues about education in museums arose, such as educational methods and techniques to improve visitors' participation in museums, and training of tour guides. Most of the discussions in the seminar focused on museum presentation of exhibitions and how this presentation affects visitors' knowledge and experience; relationships between museums and those who visit and use them; influence of museums beyond their own walls; and the role of scholars, volunteers and tour guides in the educational process. Participants of this seminar comprised educators, museographers and researchers, and concluded that close cooperation between educators and museums are necessary, and provided conclusive evidence that there is no longer need to persuade museums of their educational role.

In recent decades, multiple studies had analyzed theories of research in museums and how people acquire knowledge within their walls. These studies have focused in one or several segments of population: from children to families, from adults to tourists, and their main purpose has been to try to prove that in fact, museums are places for learning and that the encounters that visitors have

with exhibitions appear to lead to learning, and influence future behavior (Hein & Alexander, 1998). In their monograph entitled *Museums Places of Learning* Hein and Alexander (1998) stated that informing museum visitors in advance what they are going to see and what they might find makes them more comfortable, more able to engage, and thus, better able to learn. They mentioned that while pre-post tests have been used to measure what visitors learn in museums, more recent research has included a wide range of theory and practice which comprises interviews and observations with visitors and several other naturalistic approaches. This argument is supported by Screven (1986), who claimed that giving information to visitors ahead of time about what they are going to experience can help them to get focus and to organize their visit, and also by Fienberg and Leinhardt (2002) who stated in their study that "visitor groups who came to a museum exhibition with previous knowledge or experience relevant to the content of the exhibition had a greater likelihood of engaging in a more expanded way."

Hein (1998) stated that "learning does occur in museums; but unlike formal schooling, work, or recreational pursuits like chess, weaving, etc., visiting museums is not only voluntary, it usually occurs in family groups who spend only a brief time on a complex set of activities" (p. 135). Unlike other learning settings where learners engage in the tasks repeatedly to pass an exam, learning in museums is most of the times a social process that involves not only the visitor and his personal agenda, but also the larger social context in which the visit is

occurring. This claim was also supported by Falk and Dierking (2000) who adverted that learning in museums is a free-choice experience that is personally motivated and that involves considerable choice on the part of the learner as to when, where, and what to learn.

For Hooper-Greenhill (1994), one of the primary functions of a museum is education and it is the reason of its existence. Museums have to find a balance between preserving and displaying objects, and finding relationships between the museum and its public. Museum education focuses in the teaching and learning from objects and specimens and the meaning of things is not limited to one interpretation only, and almost all museums are running course for teachers which include museum or artifact teaching strategies.

Falk and Dierking (2000) observed that prior knowledge, interest, and the museum experience itself, as well as subsequent experiences affect the museum visit, and stated that in order to understand what people experience in museums, it is necessary to know much more about them and their visit than merely what exhibitions they visited and for how long.

Previous Research in Virtual Museums

As museums have started noticing the usefulness of the Internet to deliver content, they have been implementing a space dedicated to virtual visits inside their Web sites, where users can contemplate the exhibition rooms and galleries, paintings and sculptures, ceilings and windows. The advantage of these virtual

visits is that visitors can access them without having to leave their houses, or a teacher can organize a virtual tour without having to leave the school (McKenzie, 1997).

Paquet et al. (2001) developed a project named The Virtual Museum in which attempted to offer the public visualization, comparison, and manipulation of a collection of artifacts, using laser scanners and photogrammetric techniques. The authors mentioned the importance of these techniques to develop virtualized environments, specifically those pertaining virtual tourism on sites that have been closed to the general public, and concluded that virtualization of historical sites and artifacts allows user access from anywhere at any time without restrictions.

The main characteristic of virtual museums is that they offer the visitor the opportunity to engage in different activities, from touching the different objects inside the environment to reading the information about them, or creating their own exhibitions. One example is the project called The Tech Open Source (2011) where visitors can create and exhibit projects, connect with other users of the environment, prototype their projects, or even become a virtual exhibit curators. Also, Virtual museums have a unique advantage over the real life museums, in that they can recreate situations or types of collections impossible to recreate in the real places. According to Dede (1996) “the advances in computer-supported collaborative learning, multimedia/hypermedia, and experiential simulation offer the potential to create shared ‘learning-through-doing environments’ available anyplace, any time, on demand.”

The International Spaceflight Museum located in Second Life (SL) (Lemieux, 2012) offers a solar system simulation where visitors can stand in the middle of a model of the solar system, calibrate it to any date in history, and watch the planets revolve around them. Museums in SL can offer unique experiences that would be prohibitively expensive, if possible at all, in real life museums, allowing visitors to find out what it would be like to be caught in a tsunami (NOAA Island, 2012), take a rocket ship ride into space (Lemieux, 2012), or parachute from the top of the Eiffel Tower in Paris 1900 (Urban, 2007).

The project Virtual Field Trips (Gerwitz, n.d.) uses a web engine to make virtual visits. Virtual Field Trips was created to use the Internet and the web pages of the museums to offer a virtual trip inside them with a series of goals and activities the student has to execute while he is visiting the web page. All the lessons include a navigation plan, research, a scavenger hunt (series of questions to assess the activity), further activities and answers. Among the lessons offered, there are Art, Geography, History, Literature & Language, Math and Music. Unfortunately, this project was only developed in a two dimensional version, so users cannot have a sense of the spatial distribution of the places depicted.

In 2001 a group of web developers collaborated with a team of educational researchers to survey visitors to five different types of educational web sites (Schaller, Allison-Brunell, Borun & Chambers, 2002). At the conclusion of this research, the results indicated that there were differences on the

preferences between adults and children while using online learning sites. Adults selected interactive references and simulation, whereas children preferred creative play and role-playing. Interactive references, according to the authors, consist on the self guided exploration of a topic using words and pictures. Using Simulation sites, users run a model of the real world and see what happens when they change things. This study supports the participants' selection (young adults) for this thesis and the structure of the virtual environment built, which can be categorized under the interactive reference type.

Corcoran (2002) created a project named Inuit 3D which is an interactive exhibition that allowed visitors to navigate through three exhibition halls. The intention of the research was to present evidence of technical and design issues presented in these virtual environments. The researchers conducted a survey of focus groups to explore these issues and concluded that, while virtual museums still present some technical issues, in the future 3D exhibitions will become much more viable.

In 2003 a study conducted by Hendricks, Tangkuampien and Malan focused on the analysis of virtual environments for museums. They proposed a project name Contemporary African Music and Arts Archive (CAMA) to digitally capture and provide the collection in a single virtual location to the world communities. In their research, they analyzed the advantages and disadvantages of using a virtual environment to deliver this content. They examined and compared the experience between sites built using HTML (Hyper text markup

language) and those built using 3-dimensional online tools. In that case, 3D Studio Max was used to develop the environment which later was translated to a VRML (Virtual reality modeling language) world. The main focus of the research was the comparison of enjoyment, interest in the artwork, encouragement to explore, tool for learning, distraction by environment, and time spent reading. The results showed an increased interest in the artwork, enjoyment, and encouragement to explore while using the three-dimensional scene, which also encouraged visitors to explore the real gallery.

Lucey-Roper (2006) developed a project named Discover Babylon, in which an online game contained in a virtual museum was created. The main goal of this research was to build up a tool that would evaluate online learning environments for the purpose of visitors' engagement and discovery. The main research question was to discover whether this learning tool had an impact on the audience's engagement with the museum. There were two versions of the game, one that was offered in a kiosk inside the museum, and another extended one (which at the end of the research was still in development) to be taken home after the visit. The researcher used random interviews, focus group testing, and observations and discovered that several requests from teachers were made for the kiosk version to be used as a pre-museum visit tool. The researcher concluded that although there is a lot of potential in these environments, there are several limitations, which include money for the development of the virtual environments, and gamers' expectations.

Richard Urban (2007) analyzed different museums that have been using SecondLife as a virtual platform to engage and create a social interaction among users. One of them is The International Spaceflight Museum (Lemieux, 2012). It hosts exhibits and events about real-world spacecraft, rockets, and space travel. The in-world organization that manages and develops the museum is the "Spaceflight Museum Planning Group", a group of SecondLife residents from around the world who share an interest in spaceflight. These same people have created a real life organization to support the museum, and its primary goal is to create a social environment where people can enjoy lectures and presentations, and can gather and discuss the museum's exhibits.

In 2009, a group of researchers conducted a quantitative study to explore the relationship between presence and enjoyment in a virtual museum (Syaiou, Mania, Karoulis & White, 2009). They utilized the Augmented Representation of Cultural Objects system (ARCO) to develop the three dimensional space. The researchers then used two questionnaires to measure presence, which were filled by the users after experiencing a virtual museum exhibition: Slater's Virtual Reality questionnaire (as cited in Syaiou, Mania, Karoulis & White, 2009) was used to describe visitors' experience in the virtual museum compared with their experience in traditional museums; and Regenbrecht & Schubert's Augmented Reality Questionnaire (as cited in Syaiou, et al., 2009) was used to measure the degree to which individuals experience the presence of virtual objects in a real environment as the subjective impression they appear real. The questions in both

questionnaires were tied in relation to participants' usage of computers and their experience with virtual reality, augmented reality, and computer games. The participants of this research were 16 males and 23 females, and their age range was between 19 and 33 years. The results showed that previous computing experience does not induce enjoyment in a virtual environment; presence and enjoyment are related to each other; and a significant correlation was revealed between enjoyment and both augmented reality objects presence, and virtual reality presence. Researchers concluded that building a virtual environment system to match the human perceptual and motor systems is essential, and it is required to induce spatial awareness and subjective feelings of enjoyment similar to the real world.

In February of 2011, Google in conjunction with 17 museums launched a new web site named Google Art Project (2011), which uses Maps' Street View Technology to bring museums to millions of users online. With this tool users can 'walk' through the exhibition rooms, choose a panting, and zoom into it to appreciate even the minimum detail, such as brush strokes or even cracks in the paintings, which would be impossible to do in the real museum because of the different security measures implemented throughout the exhibition rooms.

Singh (2011) argued that having a virtual representation of a museum offers different advantages, such as increased accessibility to audiences around the world. However this alone is not adequate if these virtual representations

offer only a collection of images, because it limits the potential of technology as a vehicle for education, discussion, thought and reflection.

The list of examples of online museums seems to be endless. Yet, there are not many published research articles about the effectiveness and assessment of these online environments, specifically on knowledge acquisition and how they can affect visitors' discourse when they perform the visit to the real museum, thus the importance and usefulness of this thesis.

Discourse Analysis

One of the first research studies involving analysis of communication in small groups was performed by Robert Bales (1950) and published in a series of articles. This set of categories has been used in multiple researches to analyze social interactions through observation (Piliavin & Martin, 1978; Anderson & Blanchard, 1982; Rice & Love, 1987; Carli, 1989; Roter & Hall, 1989; Perakyla, 2004).

Bales proposed 12 categories of interaction (Figure 1) and acknowledged that there are three broad variables that can affect the occurrences in a certain social interaction, and those are: the personalities of the individual members, the characteristics that those members have in common, and the organization of the group. But, as he argued, there are a series of conditions arising from the nature of the social exercise which change as the group interaction moves through time.

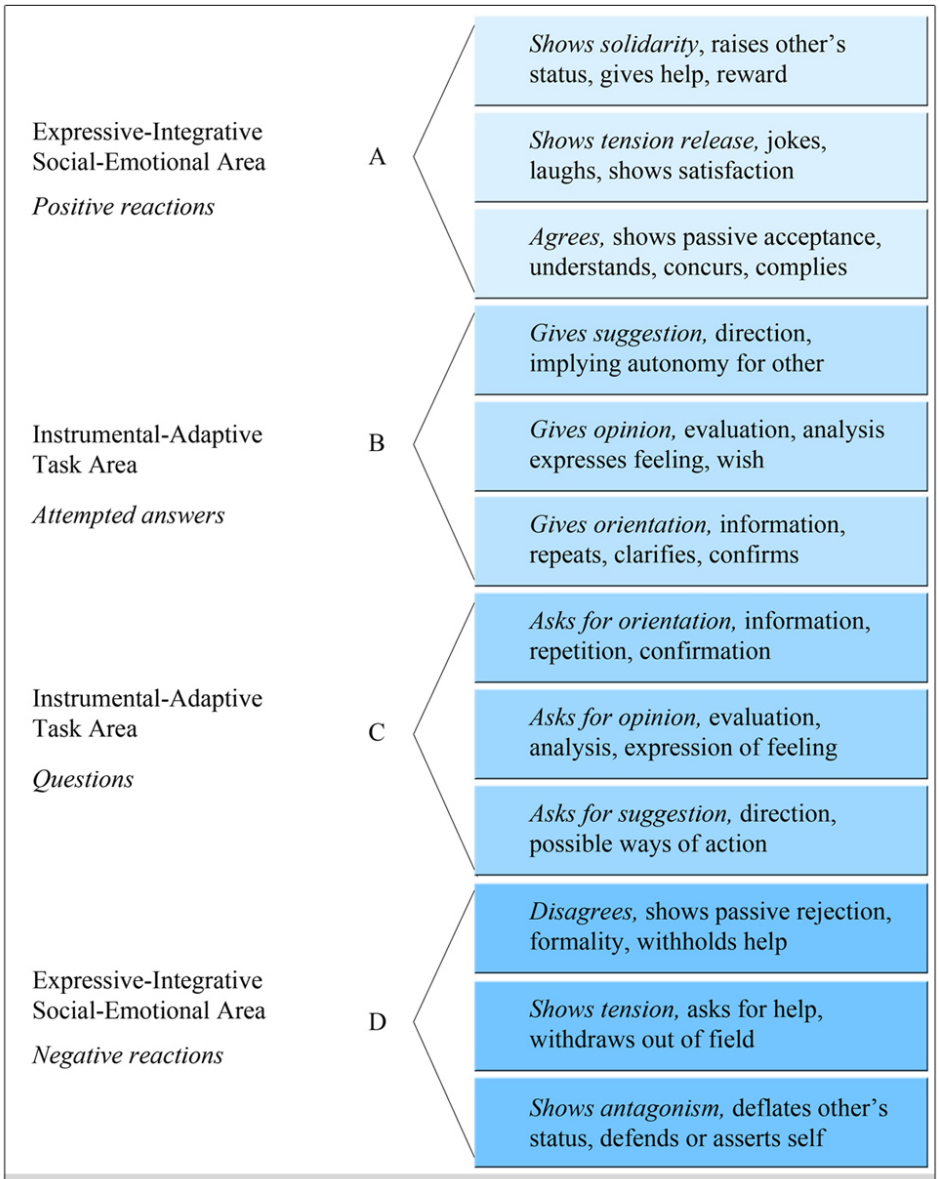

Figure 1. Bales social interaction system.

Bales placed either verbal or non-verbal acts or occurrences in these 12 categories which he defined as follow:

Shows solidarity, raises other's status, gives help, reward. Any act showing sympathy or similarity of feeling, expressing desire for cooperation, showing a nurturing attitude, complimenting or congratulating.

Shows tension release, jokes, laughs, shows satisfaction. Bales suggested that jokes are a common form of dramatization which intends to produce laugh or release tension, and included expressions of buoyancy, cheerfulness, enthusiasm, pleasure and joy in this category.

Agrees, shows passive acceptance, understands, concurs, complies. Acts that assent about facts and can include expressions of confirmation, conviction, and concurrence.

Gives suggestion, direction, implying autonomy for other. Bales included in this category any act that takes the lead in the activity, such as attempting to guide, to persuade, to inspire people to perform some actions.

Gives opinion, evaluation, analysis, expresses feeling, wish. This, according to Bales is the most frequently used category in many observation situations and it includes problem solving decisions and expressions of understanding or insight.

Gives orientation, information, repeats, clarifies, confirms. Information is given freely, and includes objective, not vague, and non-inferential statements such as "we only have 30 minutes left to finish this" or "the video is not working."

Asks for orientation, information, repetition, confirmation. This category includes all the questions that request an objective type of answer which is based on experience or observation.

Asks for opinion, evaluation, analysis, expression of feeling. This category Include all the questions seeking to get a statement involving beliefs or attitudes without limiting the nature of the answer. Examples of this category can be “what do you think about this?” or “do you understand my point?”

Asks for suggestion, direction, possible ways of action. All the acts that request guidance in a problem-solving process are included in this category, for example “what we should do next?”

Disagrees, shows passive rejection, formality, withholds help. All the verbal and non-verbal acts that disapprove another person’s statements of information or suggestion are included in this category, such as “I don’t think you are right” or “this is not the right way to do it.”

Shows tension, asks for help, withdraws out of field. Included in this category are any verbal or non-verbal acts that show conflict but do not show a negative feeling toward another person. Statements of disapproval or indications of holding back are marked as showing tension.

Shows antagonism, deflates other’s status, defends or asserts self. Any act that is negative and directed towards another person, including attempts to create conflict through continuous interruptions or other varieties of attacks of others are included in this category.

During the decades of the 1960's and 70's, several scientists, psychologists and researchers started to focus on the study of speech and language, trying to make sense of the verbal and non-verbal interactions among people. (Chomsky, 1964; Harris, 1970; Chomsky, 1972; Ross, 1973; Lisker, 1974; Fairclough, 1995; Clark, 1996; Kumar & Andreou, 1998; Fairclough 2003). The study of linguistics is divided into several disciplines that include semantics, typology, phonetics, etc.

Language, verbal and non-verbal is present everywhere and every time. Several professional areas acknowledge the study of linguistics and the study of discourse as a valuable asset. While discourse can be defined as the way people speak for which they often use mass nouns, or a written or spoken communication, Discourse (with capital D) can be defined as a distinctive way to use language integrated with other social practices (such as values, customs, behavior) within an specific group (Gee, 1999).

Johnstone (2008) stated that "discourses" involve patterns of belief and habitual action as well as patterns of language. Discourses are ideas as well as ways of talking that influence and are influenced by the ideas. According to Chouliaraki and Fairclough (1999), discourse includes language (written and spoken), nonverbal communication (facial expressions, body movements), and visual images such as photographs or film.

Gee (1999, p. 95) proposed four elements to validate discourse analysis:

- Convergence: where the answers to the questions converge to support the analysis
- Agreement: there is an understanding between native speakers and analysts of how the discourse reflects the social setting
- Coverage: The results can more or less predict what might happen in related situations
- Linguistic details: grammar of any social language conveys specific forms that are designed to carry out specific functions. According to Gee, this is an important step for the validity of the analysis.

While this research' purpose is not to perform a linguistic analysis, but rather to analyze discourse as a whole to make sense of the conversations and non-conversations taking place inside the museum, it is important to notice this element of validity as a significant one for the purposes of the study.

Rose (2007, p. 142) defined discourse as "groups of statements which structure the way a thing is thought, and the way we act on the basis of that thinking". The author introduced the term "intertextuality" which refers to the interrelation among different discourses and how each of them shapes the meanings of the others.

Analyzing and reflecting in all these definitions of discourse analysis, it can be concluded that while doing discourse analysis it is needed to take in mind not only verbal and non-verbal expressions, but also how are being conveyed, who is expressing them, and where are being showed.

Discourse Analysis in Museums

In recent years, museums have been trying to include more audiences and increase the number of their visitors (Hein & Alexander, 1998), but the study of these audiences has a 100-year history (Hein, 1998). The objective of this discipline is to understand and to enhance visitor experiences in informal learning settings through research, evaluation, and dialogue (Visitor Studies Association, n.d.)

Several papers and books about discourse analysis in museums have been written and various research projects have been published. Allen (2002) conducted a study with 49 participants to analyze visitors' discourse while attending the Frogs exhibition at the Exploratorium. The study took 20 days of data collection, and the research goal was to characterize and quantify evidence of learning in the conversations of people visiting the exhibition. The researcher provided the participants with audio devices that recorded their conversations while walking through the exhibition. Also, a tracker described and video recorded the movements of the participants while performing unobtrusive observations. These conversations were transcribed and then coded in five main learning talk categories and sixteen subcategories. The researcher discovered that almost 97% of the discussions among participants while walking through the exhibition contributed to exhibition-related learning. While the researcher was optimistic about the results, she also encountered several problems while conducting the study, specifically on tracking visitors and coding discourse. Allen

concluded that hearing or reading visitors' complete conversations is a vivid experience that also manifests the items that engages them about the exhibition.

Ellenbogen (2003) conducted an eighteen-month ethnographic case study of four families that frequently visited science museums in London. Through ethnographic research and discourse analysis the author tried to investigate how science was interactionally accomplished in the context of frequent museumgoing families. The study used hypothesis-generating observational research, field notes, and audio recordings during the museum visits, family visits to other leisure environments and while at home, and follow-up interviews after each museum visit. Data collection also involved videotaping and the collection of artifacts from visits to museums and other leisure sites. It was encountered that parents play an important role in how science is defined, and views of science were being shaped through family interactions. Focusing not only on the parents' talk at the museum but on the interactions of all the participants across environments provided adequate representation of the mediating practices. It was concluded that frequent museumgoing families "define objects from a perspective of shaping their identity, and that the museum community can develop a program of research that examines families' best practices for accomplishing science… museums and other institutions in the learning infrastructure can support these best practices" (p. 137).

In another example, Rowe (2004) analyzed a hands-on exhibit in an interactive science museum. Visitors experienced an interactive exhibit of a

plane, where they could move weights to affect the movement of the wheels of the plane. Throughout his analysis, he tried to understand how small groups of adults and children organize their activity around the exhibition and how the make meaning of it. He used two lines of text on the transcripts to describe the activity of the participants and what they were saying in that exact moment. He then analyzed not only recurrent spoken discourse but also recurrent activities among visitors. After analyzing the activities, Rowe concluded that some of them were mandatory (manipulating the weights), whereas others were optional (reading the label). He also observed and transcribed interactions among visitors to determine who was manipulating the weights using the two lines of text method.

Grek (2005) analyzed discourse in museum exhibitions and stated that researchers can study how people produce meanings and make sense of them on the basis of shared ideas and pre-knowledge. Her statement seems to support the argument of this thesis: Pre-knowledge influences visitors' experiences. Grek argued that there is a relationship between the exhibition and the process of meaning-making, the interpretation (learning process), and the explanation of the exhibit or social analysis. She analyzed an exhibition at the Verdant Works, a museum in Dundee. Visitors attended a thirteen-minute video show previous to the exhibition. This video was a significant part of the visit because it pointed out to what they were going to experience. She concluded that discourse analysis is a useful research method in museums, and that they

need to engage with the public by giving people meaningful opportunities to voice ideas and challenge beliefs.

According to Johnstone (2008), interpersonal relations among participants shape discourse, and in turn, discourse shapes interpersonal relations. She cited an exhibition at the Museum of Fine Arts in Houston called “Splendors of Ancient Egypt” where discourse analysis was used to study visitors and the exhibition itself. Johnstone further proposed six aspects of the shaping of texts (p. 123):

- Discourse is shaped by the world, and discourse shapes the world
- Discourse is shaped by language, and discourse shapes language
- Discourse is shaped by participants, and discourse shapes participants
- Discourse is shaped by prior discourse, and discourse shapes the possibilities for future discourse
- Discourse is shaped by its medium, and discourse shapes the possibilities of its medium
- Discourse is shaped by purpose, and discourse shapes possible purposes

During the analysis of the “Splendors of Ancient Egypt”, Johnstone used these six aspects to analyze the discourse between the exhibition labels, objects, and the visitors, and she concluded that the discourse of education was present throughout the exhibition and visitors embraced and were engaged with the concept.

Creating the Leopoldo Flores Virtual Museum

In this section the instructional design, selection, design, development, evaluation and implementation phases of the Leopoldo Flores Virtual Museum will be covered. The virtual museum is a replica in size and distribution of an exhibition in the Leopoldo Flores University Museum (Figure 2) that was chosen, designed, developed, tested, evaluated, and improved using 3DStudio Max and the CRG 3D Virtual Environments Framework (CRG, 2011) over a period of 9 months in 2010. It includes all the pieces, spatial distribution, information and visual thinking strategies that are being used in the real museum tours. The virtual museum client is a single user environment that was developed to be used in PC and Macintosh platforms.

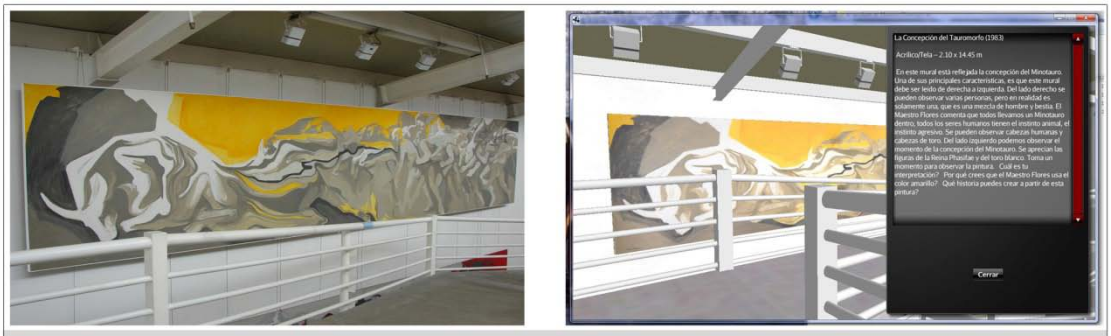

Figure 2. Real and virtual museum.

Phase 1 Museum Selection

The first objective during the pilot study (See Appendix C) was to select an exhibition that would be appropriate for the purposes of this research. Because

the users of the virtual museum can represent different demographics, the content of the museum exhibition should have to be directed to and understood by multiple audiences, and would have to be based in the situated cognition theory. According to Clark (1994) the development and delivery theories must be local in that they must apply design theories to a specific context where real people live and work. If this research gets duplicated in the future with a different culture than the Mexican one, it will have to include new content designed specifically for that particular context.

It was also important that the exhibition would be able to be replicated in an accurate way using three dimensional tools while respecting the time frame of the project, thus after visiting several museums, this particular exhibit was selected for several reasons that included a) students at UAEM, who would be selected to participate in the research, would be unfamiliar with the exhibit since it does not have high visitation, b) the collection was a self-contained exhibit space in its own building and therefore would not impacted by other aspects of a larger museum space that could influence the research, c) the number of items in the collection and the size and style of the exhibit supported both the time frame of creating the virtual replica and also limited the number of interactions with the learning space to allow measurement between the real and virtual spaces, and d) because the research was going to be conducted at the College of Architecture and Design, it was going to be easy for the participants to travel to the museum, since both are located in the same area and are close one to another.

Phase 2 Instructional Design

Although is not one of the objectives of this thesis to focus on the analysis of the instructional design of the virtual environment used for this research, it is important to mention how it was conceived and developed. The content for the environment was formulated using Paivio's (1991) dual coding theory which states that human mind comprises two independent coding systems which are verbal memory and image memory, thus the probability that visual and verbal codes can be retained more easily in memory and retrieved later for long-term memory is higher (Lin & Chen, 2007). According to this theory, visually presented information is processed in visual working memory whereas auditory information is processed in auditory working memory (Mayer & Moreno, 1998).

This system was also designed using the ADDIE model of instructional design which is a colloquial term used to describe a systematic approach to instructional development (Molenda, 2003). This model is widely recognized and has been used for several research projects involving virtual 3D environments (Boot, Nelson & DeFaveri, 2007; Wang & Hsu, 2008; Kapp 2009; Ritke-Jones, 2010; Baek, 2010).

The virtual space was conceived not only for visitors to know about that particular exhibition and visualize the paintings, but to have a sense of the spatial distribution of the paintings throughout the room. According to Galea et al. (2011) virtual architectural structures can be designed to help users acquire a spatial mental model that is on a human scale.

The space was also designed respecting and following the guidelines of the real museum tour (Figure 3). These guidelines included the same information that is presented on the museum tour, the same space proportions, and the same questions that the tour guide asks the visitors after they have been observing each of the paintings. It also includes a short introduction that narrates the story of the Minotaur before the museum tour starts.

Although the actual version of the virtual museum is a single-user environment, future versions might include synchronous multi-user interaction.

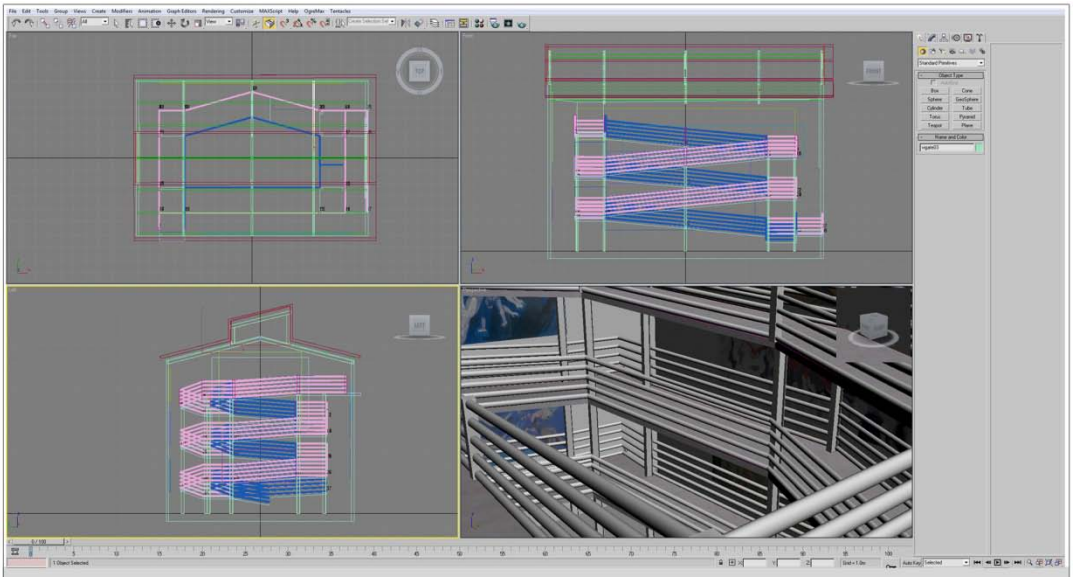

Figure 3. Digital design of the virtual environment.

Phase 3 Development

Using 3DS Max, the replica of the virtual museum was created using photos and movies of the space, along with the architectural plans provided by

the architect that designed the space. The museum also provided quality images of the paintings to be used in the environment. The primary interactions for this museum research were Spanish text, and audio narration in Spanish. A future version might be translated to English.

Although the virtual museum offers the tour both in audio and written text, the first version used in the pilot study did not have the option to stop the audio. When assessing the usability of the virtual environment during the pilot study, almost all the users suggested including a button to start or stop the sound, so the second version used for this research included it. The narrative of each of the paintings tells the story of the painting (Figure 4) itself but it also tries to encourage the users to click on the other paintings to complete the story.

Figure 4. Virtual museum.

According to Adler (1996) the auditory perception system has an enormous strength in its learning capabilities; Merabet and Sanchez (2009) stated that in order to navigate through an online learning environment

effectively, a person needs to develop sensory awareness, and Sorden (2005) declared that computer animation with narration produces better transfer than combining animation with on-screen text.

The objective is to give the visitors the same information and experience they would receive in their visit to the museum. It has been stated that vividness of the environment is a crucial factor in immersive environments where communication involves a variety of sensory stimuli (Towell & Towell, 1997). The content of the virtual environment was developed following the information that was given to the researcher by the tour guide through a guided visit of the exhibition room, which then was transcribed and a script was created based on this recording. Once the script was ready, it was sent to Mexico to the Department of Education at the Leopoldo Flores museum to be reviewed. The tour guide personally reviewed the script and made minor changes. She also suggested including questions in the script for the users to reflect on each of the paintings.

The virtual environment was then integrated into the CRG virtual environment framework (Jones & Warren, 2008). This was accomplished by creating a client shell, for windows and Mac, which contained the virtual museum that was created in 3DS max. A software engineer provided the support of converting the 3DS Max version of the museum into the OgreMax XML format, keying in the context specific points required for interaction, then placing this package into the client wrapper and testing. Then a server instance was created

on the 3D virtual server system, which aligned to the defined points in the virtual environment that were created. The engineer then programmed the information interactions into the environment using the web-based CRG authoring tool. This allowed context sensitive information to be streamed from the server to the client and be updated as required.

The virtual museum does not contain instructions of how to use it. The objective of this is to measure how difficult is for users to familiarize and to be able to operate it only receiving two short verbal instructions before using it: how to move through it, and how to click on the paintings to access the information. A future version of the virtual museum will contain a short video at the beginning that will provide an explanation of its usage.

The narrative of the paintings and space were developed directly from those given in the real tours so that the virtual environment would match the real one, and it included open ended questions given to the visitors. Although at this moment there is no way to corroborate that users of the virtual environment are answering these questions while using it, it was important to include them to try to trigger some kind of personal reflection, hence the narrative in the virtual museum presents questions such as “Why you think the artist used yellow color on this painting?” or “What story can you create from viewing this painting?”. A future version of the virtual environment might include another mechanism of assessment, such as answering a questionnaire at the end of the tour, or creating a personal reflection about the paintings in an online blog.

These digital assets were uploaded to the virtual world server and then linked to the actions within the client. Thus, when a participant clicked on an item or other event that had an action, the server streamed the required information back to client. This allowed for changes in information, flow, or interactions on the server without having to update the client each and every change.

Phase 4 Implementation

Once the client/server was ready for screening, a series of user tests were initiated to ensure the system was operating correctly. Additional tweaks were made to the user interactions points based on this phase.

The first version of the environment was tested on the fall of 2010 by an undergraduate student from Mexico who traveled to the University of North Texas before conducting the pilot study, and some issues with the translation and grammar were encountered and corrected. When traveling back to Mexico, the student took a copy of the environment to be tested in the computers at the College of Architecture and Design were the study was going to be performed, in order to confirm that the virtual museum was working properly on these machines.

Phase 5 Evaluation

All the actions and comments made by the participants in the pilot study while using the virtual environment were analyzed, and answers given by the

participants in the personal interviews and in the virtual museum satisfaction survey THSatV (See Appendix A) were also utilized to assess the virtual museum. This allowed the researchers to make some changes and to improve the virtual museum for this study. All the suggestions received during the data collection of this investigation will serve to improve the virtual environment for future research projects. Other research projects (Cobb, Neale & Reynolds, 1998; Ketelhut, 2007; Moura, 2007; Teixeira, 2009, Williams & Switzer, 2010) have been using the same mechanisms of evaluation of virtual environments such as pre and post tests, observations, and analysis of the participants' movement through these virtual places.

Pilot Study

In 2010, a pilot study about museums and virtual museums was conducted in conjunction with the University of North Texas and the Autonomous University of the State of Mexico (See Appendix C, pilot study). A group of eighteen undergraduate students from Mexico volunteered to participate, and at the end of the study only sixteen students finished all the process. The students were divided in two groups: One group took the tour in the museum and the second group took the virtual tour.

Figure 5. Participants attending the museum tour.

The next day, both groups switched and the group that used the virtual environment went to the museum tour, and the group that on the first day experienced the visit to the museum used the virtual tour. Although a computer room with enough computers for all the participants was requested to be used in the study, UAEM only provided one computer, resulting in participants taking turns to use the virtual museum.

The virtual tour was an exact replica of the real museum and it included the same content that was given to the students in the museum tour. Both groups were asked to answer a series of questionnaires and interviews to analyze, to compare, and to measure usability, student satisfaction, preferences and knowledge acquisition between the two tours.

Figure 6. Using the virtual environment.

Also, direct observation methods were used to analyze students' engagement while experiencing both tours. Although it was not the main focus of the project, the researchers noticed a difference between the discourse presented at the museum tour by students who previously had used a virtual representation of the museum tour and those who didn't have the virtual experience.

While the students who had not previously used the virtual environment showed no engagement and almost no participation during the museum tour, the ones who had had the previous experience with the virtual environment were more engaged, participative, and overall they declared they were able to enjoy the visit to the museum because they already knew what they were going to find. The museum guide who was the first to introduce the researchers with this

particular information also attested the difference in attitudes and discourse in both groups.

After reviewing the videotapes of the two sessions in the museum, researchers also noticed increased participation and engagement from the group that previously used the virtual environment, however no further analysis was made. This situation required a new research to measure the impact that a virtual environment can have in the discourse, attitudes and engagement that visitors show in a certain museum exhibition, and to analyze if visitors experiencing a virtual museum tour have the same knowledge acquisition than the ones visiting the museum. A replication of the comparative analysis will allow the researchers to validate facts (Glaser & Strauss, 1967).

Methodological Background

The majority of museum research involves visitor studies and comprises a wide range of methods to gather data. Hein (1998) mentioned some methods that include tracking and timing, traditional tracking, structured observations, event-based observations, naturalistic observations, questionnaires or surveys, comment cards, participant journals, pre and post-tests, interviews, critical interviews, focus groups, visitors' conversations, etc., and attested and recognized the need of using more than one method in the research or evaluation in museum studies. He grouped these methods into three broad categories:

- Observing what people do
- Analyzing visitors' speech, either talking to them or asking them to write about it
- And examining some product of human activity

Glaser and Straus (1967) stated that both qualitative and quantitative researches in some instances are necessary to verify, and to provide different forms of data on the same subject, which when compared, will generate theory.

For Creswell (1994) studies involve the exploration of a single entity or phenomenon bounded by time and activity, and collect detailed information by using a variety of data. In this particular research our phenomenon was the differences –if any- presented by two groups of students while experiencing a museum tour. Data collection techniques such as observation, individual interviews, and surveys were used to collect data.

Allen et al., (2007) argued that museum practitioners have been struggling to find a way to identify and to measure key concepts such as motivation, engagement or learning in museums, and presented some principles and methodology for museum research which included using a two-group study where visitors are randomly assigned, and one group does not have access to a particular experience, then both groups get to be interviewed. The authors proposed a methodology which applies methods such as interviews or observations; and suggested assessing credibility by presenting a believable study which has been approved by the people who provided the information

gathered during the study. The authors provided with suggestions to develop the research instruments and proposed the "*decentering translation*" process (p. 242) when doing a multicultural research, which consists in developing the instrument in one language, translating it to the second language, and then translating it back to the original language to verify the quality of the original translation.

Description of the Instruments Used for the Study

Participants answered a short survey about technology usage.Tthis instrument has previously used in other research projects (D'Alba, Gratch & Jones 2010; D'Alba & Gratch 2010; D' Alba Najmi, Gratch & Bigenho, 2010) and it includes 12 questions with multiple answers (See Appendix 1, instrument THDemo). The first two questions aimed to understand for how long the participants had been using the internet and software for computers. Participants chose among four answers that allowed the researcher to code them in four different brackets: Less than a year, more than a year but less than two, more than two years but less than three, and three or more years. The next ten questions aimed to measure how often participants use different technologies such as e-mail, blogs, or online games. Answers were divided in four brackets: Never, 1-2 times per week, 3-4 times per week, and Daily. This instrument was first developed as a scholarly project to measure technology usage in a virtual environment depicting the Learning Technologies Department of the University of North Texas.

Participants also answered two satisfaction surveys after using the virtual environment, and after visiting the museum to further strengthen participants' discourse analysis. The virtual museum survey has 21 questions (Instrument THSatV, see Appendix A) related to their experience while using the environment. A 6-point Likert-type scale was used to complete the survey and will contain the options "Strongly agree", "Moderately agree", "slightly agree", "slightly disagree", "Moderately disagree" and "Strongly disagree". The Likert scale is one of the most widely used instruments for measuring opinion, preferences and attitudes (Leung, 2011). Prior to analysis of participants' responses, the first 12 questions of the instrument pertaining satisfaction with the virtual environment were evaluated for reliability using Cronbach's alpha. Reliability analysis of the survey instrument, loading all 12 questions including 3 reversals, yielded a Cronbach's α of .790. Reversal questions (3, 4 and 8) were eliminated and the alpha increased to .882. The second set of questions (13 to 21) referring to the usability of the virtual environment were evaluated for reliability using Cronbach's alpha. Reliability analysis of the survey instrument, loading all 9 questions including 1 reversal, yielded a Cronbach's α of .383 with 15 valid cases. Reversal question number 19 was eliminated and the resultant alpha was .384. Since in the pilot study this set of questions presented an alpha of .824, both data sets were merged to see if the value could increase having more valid cases. The result was an alpha of .842 with 31 cases, which is considered as a good internal consistency (DeVellis, 1991).

For the museum tour, the instrument MV-Q01 (see Appendix A) was used and it contains twelve questions with the same six point Likert-type scale answers as the one in the virtual museum survey. These two surveys have been previously used in another research project which aimed to measure satisfaction in a virtual environment (D'Alba & Gratch 2010). Prior to analysis of participants' responses, the survey instrument was evaluated for reliability using Cronbach's alpha. Reliability analysis of the survey instrument loading all 12 questions including 3 reversals yielded a Cronbach's α of .436. Reversal questions (3, 4 and 8) were eliminated and the alpha increased to .598. Since in the pilot study this set of questions had an alpha of .864, both data sets were merged to see if the value could increase having more valid cases. The result with 42 valid cases and 1 excluded was an alpha of .732 which is considered as an acceptable internal consistency (DeVellis, 1991).

All the instruments used for this study were first written in English language, translated to Spanish, and after that, reviewed and translated back to English to assert the quality of the original translation.

Summary

This chapter introduced literature relevant to critical discourse analysis, museum studies and research in virtual museums. Major theoretical approaches and situated cognition in museums were exhibited. The instructional design of the pilot study in virtual museums conducted in Mexico in 2010 was also

discussed. Literature in assessment in a situated learning environment and pre-visualization were analyzed. The methodological background and validity of the study were presented. The next chapter exhibits the research methods, the data collection process and delivers issues of rigor and trustworthiness.

CHAPTER 3

RESEARCH METHODS

In this chapter, research methods and procedures for data generation are discussed, a description of the participants, the development of the research, and research setting will be submitted, and issues of rigor and trustworthiness will be exhibited. A section discussing the research questions and how were addressed during the research process will be presented.

The following mixed-methods study allowed the researcher to analyze participants' attitudes, knowledge acquisition, and discourse while experiencing a museum tour, and to compare them between two groups of students, one of which had a previous visualization using a virtual tour before the museum tour. The results of the research, as well as participants' personal information were handled in accordance with the University of North Texas Institutional Review Board (IRB) guidelines and approval process. Real names of participants were not used in this document when discussing findings, and instead aliases and participants' numbers were utilized.

Quantitative non-parametric measurement was used to determine user's technology usage and to cross-examine this information with knowledge acquisition and other topics that arose during the research. Rank-sum scaling is

a common method of tallying participants' preference given to scalable objects when those objects are arranged in all possible pairs, allowing votes of preference to be mapped on a linear scale of zero to one-hundred (Dunn-Rankin et al., 2004). Rank-sum scaling is a reworking of two-way variance analysis by ranks, and as a result, is nonparametric because the data is two-way.

Knowledge acquisition performance was graded using three different tests with 10 questions each about the information contained in the exhibit (See Appendix A for instruments). Based on the quantitative results and direct observations during the course of the research, semi-structured personal interviews to all participants, and a group interview took place to add further information to the collected data and analysis (Creswell, 1994).

Research Questions

The methodology presented in this Chapter helped to provide with answers to the research questions as follow:

The main research question was:

In what ways does a pre-visualization of a virtual museum affect the museum experience? This question was examined by analyzing participants' individual interviews and observation during the museum visit. The answers provided by participants during their personal interview, and during the group interview were also used to corroborate findings in the instrument MV-Q01 Museum Tour Satisfaction (see Appendix A). Carspecken's (1995) system

allowed the researcher to code the transcripts from the individual interviews in several categories, and Bales interaction system (1950) was used to code and to categorize participants' attitudes and discourse –verbal and non verbal- during the museum visit.

Sub-questions:

In what ways visitors discourse is affected by previously experiencing a self-guided virtual tour of the same exhibition? This question was examined using Bales social Interaction system that allowed the researcher to code into 12 different topics all the participants' discourse and attitudes throughout the museum visit. Observation field notes were also helpful to respond this inquiry. Answering this question also reinforced the answer provided to the main question of this dissertation. Participants' individual interviews and the group interview confirmed findings to this question.

Can users of a self-guided virtual tour show gains in knowledge acquisition? This question was examined using the pre and post-tests provided before and after the virtual museum usage, and then corroborating these findings during the individual and the group interviews, and with the instrument THSatV Virtual Tour Satisfaction (See Appendix A).

Can visitors who use a self-guided virtual tour and then attend the real museum tour show gains on knowledge acquisition, vs. those visitors experiencing only a museum tour? This question was examined by comparing

the results from the pre and post-tests from both groups of participants, and then corroborating findings during the personal interviews.

Research Setting

This research was conducted on the second exhibition room of the University Museum Leopoldo Flores, which is sponsored by the Autonomous University of the State of Mexico (UAEM). The University sponsors six museums and the museum selected for this research was designed and is dedicated almost exclusively to show the work of Mexican artist Leopoldo Flores. The artist was born in the State of Mexico and has become a recognized painter and muralist around the world. The museum was built in 2001, opened to the public in 2002, and holds 378 works of art. It also has a studio for workshops, library, and an area for temporary exhibitions. The second exhibition room, or Room B, which is the focus of this research, holds a series of eleven works of art named “The Minotaur in the Labyrinth” or “Ariadne’s thread.”

Some of these paintings are as large as 14 feet by 7 feet (Figure 7) and depict the story of the Greek myth of the Minotaur, a creature half man and half bull that was locked in a maze built by Daedalus. The myth says that every year seven youths and seven maidens from Athens were fed to the Minotaur, until Theseus entered the maze and killed the Minotaur with the help of Ariadne, who was the Minotaur’s half sister. Leopoldo Flores used this story to develop the paintings that are presented in this exhibition room, which was designed to look

like a maze, with patrons walking along a spiral ramp that lead them to the bottom of the room. The museum offers guided visits to this and other exhibition rooms, and it also offers story telling within its walls. The objective of the guided visits or tours is to create a communication process that will allow the exchange of knowledge, thoughts and feelings (Abraham, Hernandez & Gomez, 2005).

Figure 7. Detail of the painting Minotaur's dance.

Participants

A group of twenty-seven undergraduate students in their first semester at the College of Architecture and Design of the Autonomous University of the State of Mexico offered to participate in the research. The College offers three undergraduate degrees, two master degrees and one doctorate degree.

To invite participants, the department chair and the researcher went to three students' classrooms and gave them a brief overview of the project. Students interested in participating wrote their names, phone numbers, and emails on a list. The only requirement for them was not to have previous knowledge of the exhibition "The Minotaur in the Labyrinth". Selecting participants from a single population reduced the possibility that differences between the two groups would cause differences in outcomes. Minimizing these differences increased the possibility that data collected on a given category would be similar (Glaser & Strauss, 1967).

Participants were placed in one of two groups, these two groups were randomly assigned (Russell, 2011) and all the participants had to sign the consent form (Appendix B) before commencing the research process. Each participant had a unique number assigned to them which they used throughout the research process to identify themselves. Participants had to write down this unique number in each of the instruments provided (See Appendix A). Also, at the beginning of the individual interviews, the researcher mentioned the participant's number and an alias assigned to each of the participants in order to protect their real identity. This alias was also used throughout this document when quoting comments made by the participants, or mentioning them when analyzing the results of the study.

The first group defined as bothtours group experienced a virtual tour before they visited the museum, and the second group defined as onlymuseum

group did not have access to the virtual environment and only visited the museum. A series of semi-structured interviews were asked to the students after experiencing the virtual and the real museum visits, as well as questionnaires to measure knowledge acquisition. This methodology allowed the researcher to analyze other themes and issues that emerged during the research during this research project.

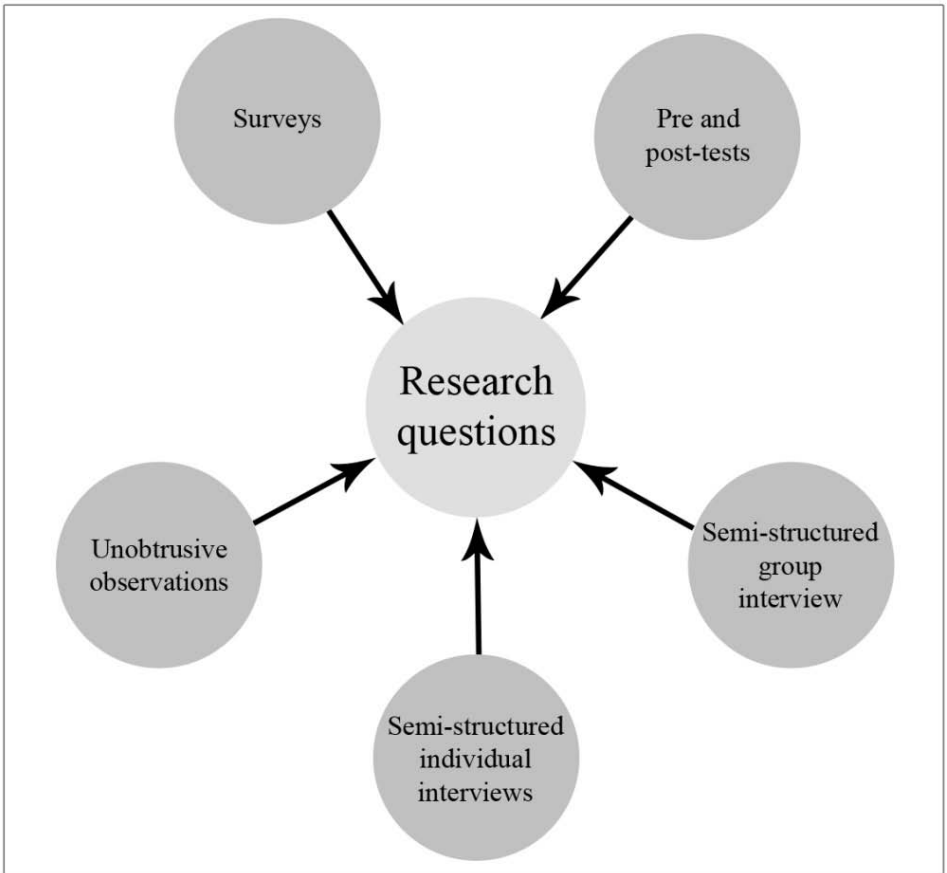

Figure 8. Methods used in the research.

Research Methods for Data Generation, Collection and Analysis

Development of the Research

Both groups were randomly divided. To achieve this, participants were assigned consecutive numbers, following the order in which they wrote their names on the participation list; odd numbers went to bothtours Group and even numbers were assigned to onlymuseum Group.

The following is an overview of the timeline for the delivery of the research:

Day 1. On the first day of the research, there were two separate meetings with each of the groups in which the project was briefly explained to the participants. They also were asked to not discuss any information concerning the research process with their peers. The purpose of this was to try to avoid bias which could occur (Higgins & Altman, 2008), since all the students belonged to the same school setting and shared several classes during the day. The objective of having two separated meetings was to reduce the chance that participants knew who was in the other group, not allowing them to discuss the project and minimizing the mentioned bias.

All the participants were given the IRB consent form (Appendix B), and had to complete the first knowledge test related to the theme and the artist of the exhibition (Instrument THpre01, see Appendix A). Both groups completed a short

survey about technology usage and basic demographics (THDemo, see Appendix A).

All participants were provided with a printed schedule containing their name, number assigned, and all the locations, times of the day, and activities they were going to be performing, including individual interviews, museum visit and group interview.

The onlymuseum group was dismissed for the day. The bothtours group then moved to the computing lab to use the virtual environment. This session was recorded on video. Before they started using the virtual museum, a short verbal explanation of how to navigate through it and how to access the information of the paintings was given to them by the researcher. After bothtours group finished, all of participants completed a second test with different questions related to the theme and the artist (Instrument THpos02, see Appendix A).

Day 2. Both groups attended a guided tour at the museum at different times during the day. After they finished the tour, all the participants were asked to complete a third test to measure learning outcomes (Instrument THpos03, see Appendix A). These visits were recorded on video tape, and participants answered a short survey about their museum experience (Instrument MV-Q01, see Appendix A).

*Day 3.*On the third day of the research, individual interviews with all the participants were performed using semi structured questions that later were used to triangulate information. These interviews were recorded on videotape (See list

of questions in the THindv01 Personal Interview, Appendix A). Some of the participants were asked to clarify their answers to the previous instruments.

*Day 4.*On the last day of the research, both groups met at the same time in the college auditorium to listen to a detailed explanation of the research, and they were encouraged to have an informal discussion about their perception and opinions concerning the investigation and the preliminary results. Another set of semi-structured questions was used to gather information and this group meeting was also video recorded (See Appendix A, Group interview questions).

Knowledge Testing and Participants' Attitudes

Pre and Post-tests

Pretests and post-tests were performed in both groups to measure knowledge acquisition. The pre-test tried to determine participants' baseline knowledge about the artist and the pieces displayed at the museum. The Post-test results served to compare and to differentiate the knowledge that the participants acquired during the research. Basic demographic questions such as sex and age were asked (Ryder, 1985). Pretests and post-tests contained multiple-choice questions about the exhibit and the artist, and these items consisted in two basic parts: A question, and a list of suggested solutions or alternatives. This list included one correct solution and a number of other incorrect alternatives. Using multiple-choice questions reduced the time of scoring, and obstructed any scoring inconsistency that could be presented while

assessing an essay question (Burton, et al., 1991). To analyze the results of these series of questionnaires, a one-way analysis of variance (ANOVA) was used (Anscombe, 1948). At the beginning of the research, all the participants had to answer the first test; then bothtours group answered a second test after finishing the virtual tour, and at the end of their visit to the museum tour both groups answered a third test. Data analysis allowed the researcher to test for differences in knowledge acquisition between the two groups, comparing the results on the three tests. bothtours group answered all three knowledge tests, and onlymuseum tour answered the THprep01 pre-test and the THpos03 post-test (See Appendix A).Because of the lack of computers provided for the study, all three tests as well as the surveys were provided to the participants on hard copy and they had to fill them out by hand. The researcher reviewed all these instruments as soon as the students returned them, to corroborate that there were not unanswered questions.

Semi-Structured Interviews

Semi-structured interviews to know participants' experience and opinions using the virtual environment as well as their experience and opinions visiting the museum were conducted. An interview is a data collection method in which participants provide information about their behavior, thoughts or feelings in response to questions posed by an interviewer (Crano & Brewer, 2002). According to Cohen and Crabtree (2006) semi structured interviews are best used when the researcher will not get more than one chance to interview the

participants, and they are often preceded by observation. Although interviews are not the most important source of qualitative data, they can be used to compare results with other sources to generate sociological theory (Glaser & Strauss, 1967). Open-ended questions allowed the informants to answer from their own frame of reference rather than being confined by the structure of pre-arranged questions and informants express their thoughts more freely (Bogdan & Knopp, 2002). These questions allowed more questions to emerge in the course of the interviewing and some of them replaced the pre-established ones (Glesne, 2011). The conversations then were coded and grouped into similar topics using Carspecken's (1995) coding method that uses codes and subcodes attached to numbers or letters that are typed on a word processor in an attempt to classify conversations in similar categories.

Direct Observations

Direct observations allowed the researcher to study a phenomenon in its natural setting (Cohen & Crabtree, 2006). These non-participant observations were achieved by attending both museum visits and watching and video recording the participants while experiencing the museum tour. In both museum visits, continuous monitoring was performed and several field annotations were generated, which means that the researcher was trying to record the group behavior as faithfully as possible without interfering in the process of the activity (Russell 2011). Videotapes could be examined frame by frame and be played and replayed, to do further analysis (Glesne, 2011), and these videotapes

allowed the researcher to observe further details such as intonation or body behavior (Cohen & Crabtree, 2006).

Bales' "Interaction process analysis" system (Bales, 1950) was used to code these observations in twelve sub categories (see Chapter 2, discourse analysis section). This coding method was developed in an attempt to solve the semantic vagueness of different observation processes (Bales, 1999) and it has been used in multiple qualitative research projects that involve group interaction.

Rigor and Trustworthiness

Many qualitative researchers have proposed different strategies to validate research (Lincoln & Guba, 1985; Padgett, 1998; Creswell, 1998; Glesne & Peshkin 1992). This study was based on three strategies to enhance the rigor of validation:

- Although I have knowledge of the environment as a native of Mexico, as a past student at the College of Architecture, and as a past teacher at the same place, the limited amount of time provided for the data collection prevented prolonged engagement.
- Triangulation was attained using unobtrusive observations, personal interviews, group interviews, surveys, and pre-post tests.
- Peer debriefing and support was achieved asking colleagues to enounce comments and criticism of the research process and data analysis during the dissertation proposal defense.

There are four issues of trustworthiness that needed to be addressed: credibility, transferability, dependability and confirmability (Lincoln & Guba, 1985; Padgett 1998). Credibility was achieved by asking the participants of this study to validate and judge the believability of the results. Releasing the instruments used for the study, and describing the research content and process in depth so other researchers can transfer the conclusions of this research to their content achieved transferability. Dependability and confirmability were achieved by asking peers to review this research process and its results, allowing them to examine field notes, videos, audio, data analysis documents and the dissertation document.

Summary

In this chapter, the research setting for the research project, participants', and how they were recruited were introduced. Research methods and procedures for data generation that are going to be used in this research were presented. Semi structured interviews, observation, and pre-post test methods were analyzed. A full description of the development of the research was exhibited, and rigor and trustworthiness issues were addressed.

In the next chapter, data analysis, field notes, and results of the research are presented.

CHAPTER 4

DATA COLLECTION

This chapter presents the analysis of data collected in this investigation. Participants' answers to different instruments used throughout the four days of data collection will be exhibited, several participants' quotes will be also introduced, and groups' attitudes and discourse in the museum visit will be delivered.

Participants' Demographics and Technology Usage

An initial group of thirty students volunteered to participate in the research. All participants were in their first year of study at the college of Architecture and Design at the Autonomous University of the State of Mexico (UAEM). All of them declared they had never attended the Leopoldo Flores exhibition before; also all the participants knew each other since they were taking at least one class together. The thirty participants were randomly placed in two groups: Bothtours group and onlymuseum group, each with 15 participants. By the end of the research all of bothtours group participants completed the research while only 12 participants from onlymuseum group finished it, for a total of twenty seven participants completing the research.

Participants' age ranged from 18 to 22 years. Fifteen (55%) were 18 years old. 19 (70%) were female. 93% of the participants (25) declared that they had been using computer's software for three years or more, 96% (26) had been using internet for three years or more.

Table 1

Participants Demographics

Sex	Total	%
Male	8	30
Female	19	70
Experience using software	**Total**	**%**
3+ years	25	93
2 to 3 years	2	7
Experience using internet	**Total**	**%**
3+ years	26	96
2 to 3 years	1	4
Computer usage	**Total**	**%**
Every day	23	85
3-4 times per week	4	15
E-mail usage	**Total**	**%**
Every day	18	66
3-4 times per week	9	34
Social networks usage	**Total**	**%**
Every day	16	59
3-4 times per week	9	34
1-2 times per week	2	7

Twenty-tree (85%) participants use the computer every day, 15% (4) use it three or four times per week. Participants were surveyed on their use of technologies such as email, online games or online social media. 48% (13) of the

participants declared that they never play online games such as World of Warcraft. Only three participants (11%) declared that they play online games every day.

The majority of the participants (60%) indicated they use social networks such as Facebook or Myspace on a daily basis. 33% use social media three or four times per week. 63% (17) of the participants send or receive instant messages through their cell phones every day, 30% declared sending or receiving instant messages three or four times per week. 44% (12) declared they read blogs three or four times per week but only 3% (1) declared writing blogs on a daily basis

This study presented a correlation between gender and playing online games. The three participants that declared playing online games such as World of Warcraft, Diablo, or Age of Empires on a daily basis were male. Two female participants declared that they play online games three or four times per week.

Knowledge Acquisition Between Groups

At the beginning of the research both groups were asked to answer a pre-test containing ten questions related to the artist and the exhibition to discover what was their previous knowledge about these topics. Appendix A contains the tests that were administrated during the research to examine knowledge acquisition, and further details from this data collection phase were mentioned in Chapter 3 in the ‘Development of the Research’ section.

Bothtours group scored a median of 27% questions answered correctly. Onlymuseum group scored a median of 31% questions answered correctly. After bothtours group used the virtual environment, they were again asked to answer another set of 10 questions. The group scored a median of 67% questions answered correctly (see instrument Tpos02 in Appendix A) with the highest individual score going from two questions answered correctly to ten questions answered correctly, and the lowest individual score going from two questions answered correctly to five questions answered correctly.

After both groups visited the museum and had the guided tour, participants were asked to answer the final set of questions related to the exhibition and the artist. The instrument was the same for both groups (see instrument THpos03, in Appendix A). Bothtours group scored a median of 51% questions answered correctly and onlymuseum group scored a median of 30% questions answered correctly. Figure 9 shows the results of the three tests given during the research to measure knowledge acquisition at different stages.

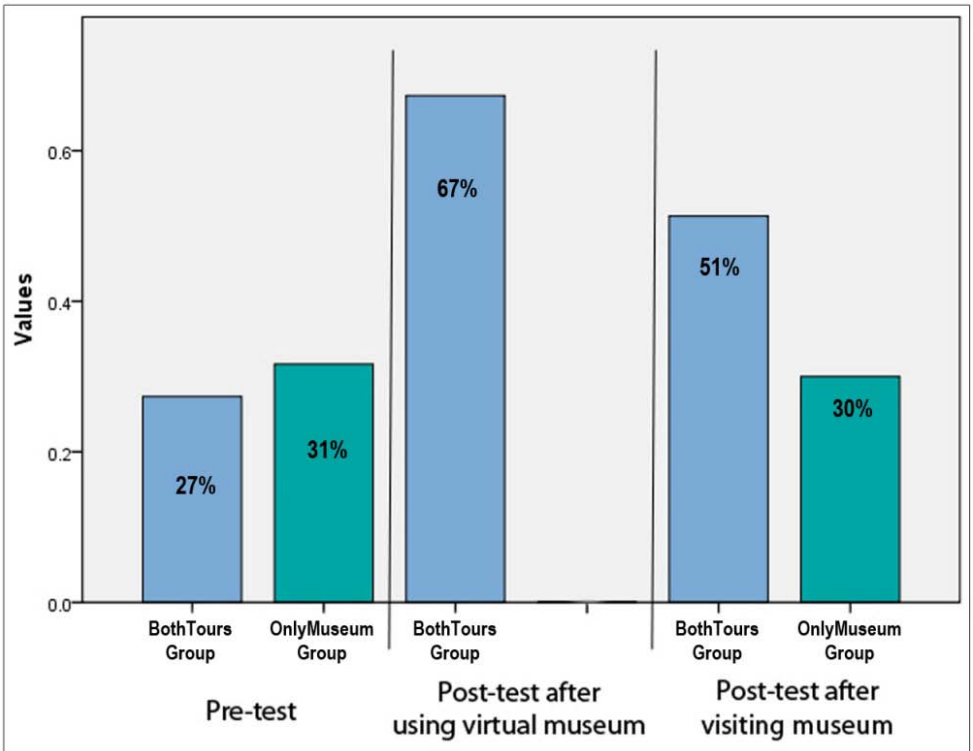

Figure 9. Test Outcomes.

Perception and Satisfaction in the Museum Visit

Participants were asked to answer a series of instruments to measure and to compare satisfaction and perceptions between the virtual environment and the museum tour. The instruments were created and tested in earlier research and in the pilot study (D' Alba, Najmi, Gratch, & Bigenho, 2010; D'Alba, Gratch, & Jones, 2010) After the museum tour was completed, participants were given the Instrument MV-Q02 Museum Tour Satisfaction, (See Appendix A, questions 1 to 12). When asked if the visit to the museum had been captivating, 66% of the

students (18) strongly agreed and 34% moderately agreed (9). When further analyzing the answers between the two groups of participants, it was discovered that 60% of the participants from bothtours group strongly agreed with this sentence, compared to 75% of the participants from onlymuseum group that had the same answer.

Figure 10. Participants answering the surveys.

When asked if the visit to the museum was enjoyable, 80% of the participants (12) of bothtours group strongly agreed, and 14% (2) moderately agreed. Kalden (All the names presented in this study are aliases), strongly disagreed with this statement. During the individual interview, Kalden was asked to clarify his answer. He stated he had not liked the paintings, the guided tour, the space, or the tour guide. He did not further clarify.

92% of the participants of onlymuseum group (11) strongly agreed the museum visit was enjoyable and 8% (1) moderately agreed.

Participants were asked to reflect on the statement “My visit to the museum was fun” (Figure 11). 60% (9) of the participants belonging to bothtours group strongly agreed with the statement, while only 25% (3) of the participants of onlymuseum group strongly agreed with the same statement. 58% of the students of onlymuseum group (7) moderately agreed, one participant slightly agreed, and one participant slightly disagreed.

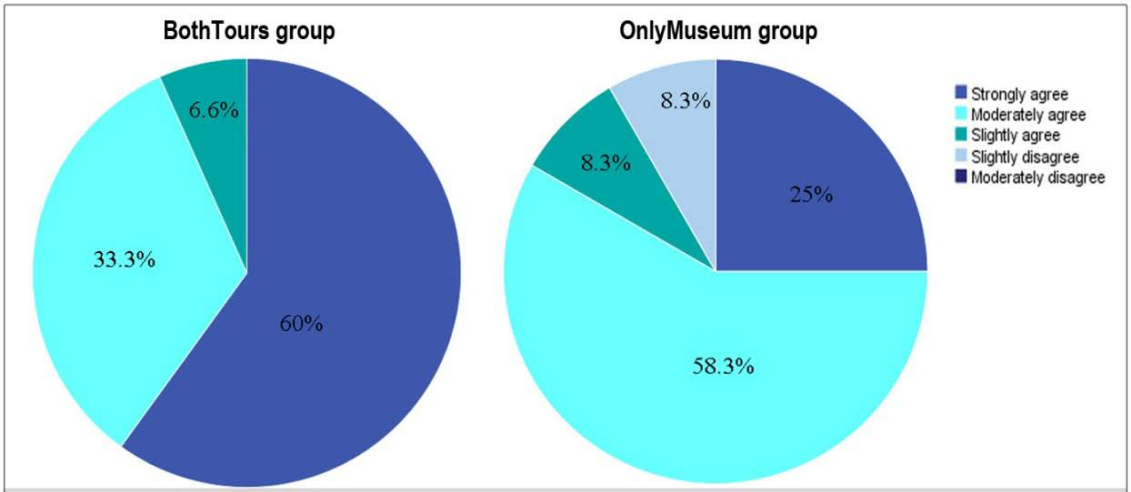

Figure 11. My visit to the museum was fun.

Participants were asked to give their opinion about the statement “I think I learned something from my visit to the museum”. 73% of the participants of bothtours group (11) strongly agreed with this statement, 20% moderately agreed (3), and Sharon slightly disagreed. During the personal interview Sharon was asked to clarify her answer and she declared that because she already knew what the exhibition was about, she felt she did not learn anything new and that is

why she answered in that way. It is important to mention that Sharon belonged to bothtours group and she already had experienced the virtual museum. 83% of the participants of onlymuseum group (10) strongly agreed with the same statement and 17% (2) moderately agreed.

When asked if the museum tour offers enough information about the artist/pieces in the collection (Figure 12), 53% of the participants (8) of bothtours group strongly agreed and 47% (7) moderately agreed. Only 25% of the participants (3) of onlymuseum group strongly agreed with this statement, 50% of the participants (6) moderately agreed, 17% (2) slightly agreed, and 8% (1) slightly disagreed.

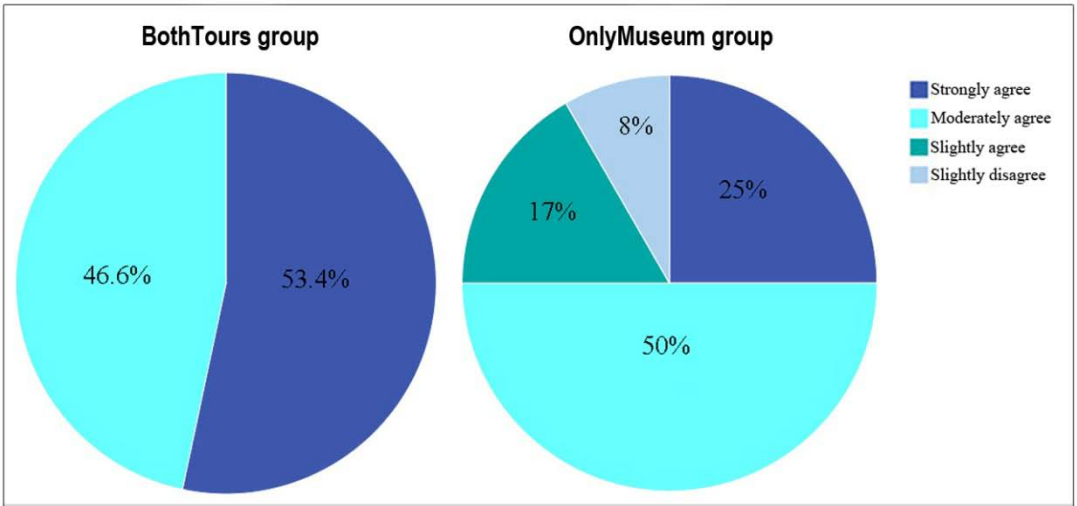

Figure 12. The museum tour offers enough information.

Participants were asked to agree or disagree if the museum visit motivated them to seek more information about the artist/pieces in the exhibition (Figure 13). 46% of the participants of bothtours group (7) strongly agreed, while

only 25% of onlymuseum group (3) chose the same answer. 26% of the participants (4) of bothtours group moderately agreed while 50% of onlymuseum group (6) also moderately agreed with this statement.

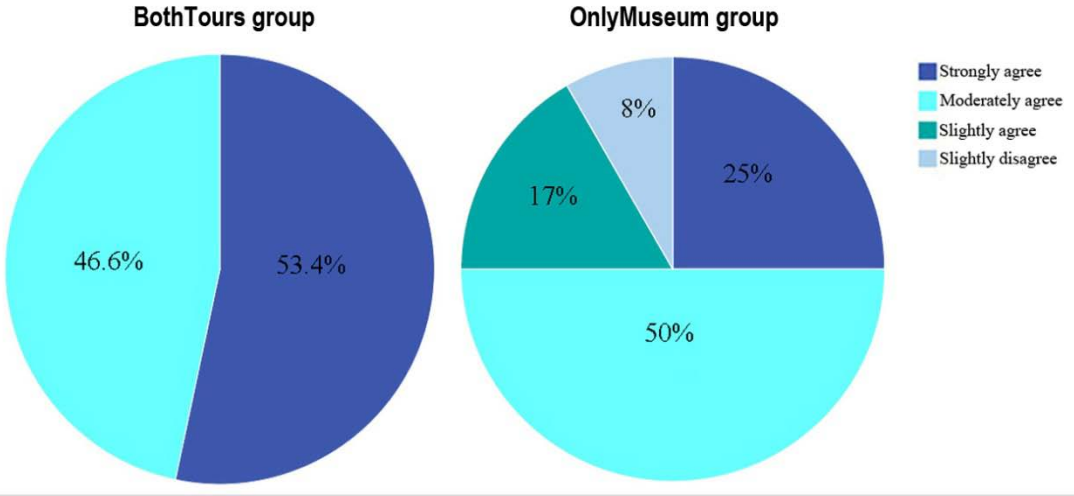

Figure 13. Encouragement to seek more information.

Perception of the Virtual Museum by Bothtours Group

The average time spent by the participants using the virtual museum was 17 minutes. After the virtual museum usage, participants of bothtours group were asked to answer a series of questions about their perceptions related to the virtual environment. These questions are included in the instrument THSatV Virtual Tour Satisfaction questions 1 to 12 (see Appendix A). The objective of this set of questions was to analyze participants' opinions and then to compare them with their answers on the personal interviews. Answers that seemed different from the rest of the participants were marked and then, during the individual

interviews were asked to clarify. The instrument also included a series of questions about usability of the virtual museum.

Forty percent of the participants (6) strongly agreed and another 40% moderately agreed with the statement “Using the virtual museum is captivating”; 60% (9) considered the virtual museum fun and enjoyable. Festus and Kalden did not find the virtual environment captivating. During the individual interview both were asked to clarify their answers. Festus said the virtual environment lacks visual quality and that is why he did not find it captivating. When furthering analyzing his answers, it was noted that he is an avid gamer that declared playing online games such as World of Warcraft, Diablo or Age of Empires on a daily basis.

Kalden showed similar interest in online games. During the personal interview he declared himself as a “technology geek”, he felt the virtual environment was not completely developed, and also he said he would have liked the virtual environment to be more realistic, especially when showing the paintings.

Sixty percent of the participants (9) strongly agreed with the statement “I think I learned something from using the virtual environment.” When comparing their answers to this question to the answers given to the question "I think learned something from my visit to the museum", the difference is noticeable (Figure 14).

Overall, 93% (14) of the participants from bothtours group strongly or moderately agreed with the statement “I think I learned something from my visit

to the museum" compared with 80% (12) of the participants that strongly or moderately agreed with the same question regarding the virtual museum.

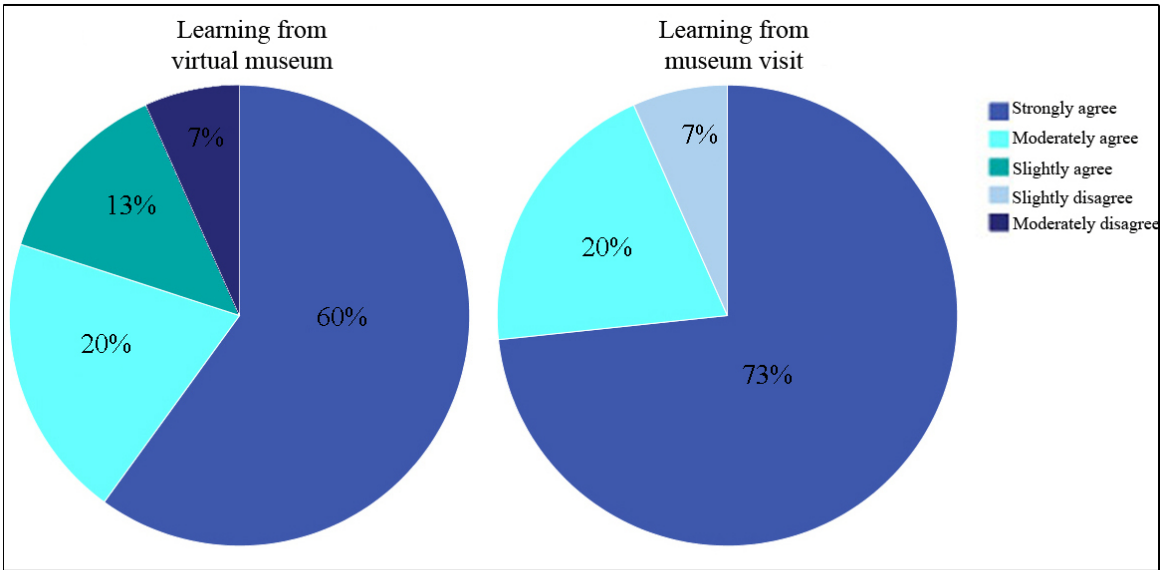

Figure 14. Opinion about learning in both settings.

Kalden moderately disagreed with this statement. During the personal interview he was asked to further comment on the issue. He felt he did not learn from the virtual environment because he preferred the real museum visit, however, a contradiction was found about this statement and his previous statement from the museum visit when he declared he did not like the paintings, the guided tour, the space, or the tour guide.

Analyzing all the videos, it was noted that during his session using the virtual environment he experienced several internet shortages, which resulted in the environment not displaying the paintings and the information properly; he showed frustration about this issue. This technical problem affected his experience with the virtual environment and might have affected his overall

participation in the study; during the museum visit he was quiet all the time and seemed disinterested in the tour. He was very reluctant and did not speak a lot during his personal interview, most of his answers were short and when asked to clarify further, and his answers were similar to "I don't know what else to say". During the personal interview he mentioned the technical issue he experienced and he also declared he did not like the voice that narrates the content in the virtual environment. However, further on the interview, when asked from which of the two visits he learned more, he declared he learned more from the virtual environment, his answer was: “I think I learned more from the virtual because it is better if you read the information of the paintings and you get more from the reading, rather than listening to it from the tour guide.”

When asked if the virtual museum offered enough information about the artist and pieces in the exhibition, 60% (9) of the participants strongly agreed and 33% (5) moderately agreed, compared with 53% of them (8) strongly agreeing and 47% (7) moderately agreeing when asked if the museum offered enough information about the artist and the pieces.

Eighty percent of the participants (12) strongly or moderately agreed with the statement “I would like to explore other collections using the virtual museum.” Festus slightly disagreed with the statement. During the personal interview, Festus was asked to clarify his answer. He said that although he believes is a great idea to offer a virtual museum, he believed the virtual environment needs more graphic quality.

Usability of the Virtual Environment

Participants of bothtours group were asked to answer a series of questions about usability of the virtual museum. The questions are contained in the instrument THSatV, questions 13 to 21 (see Appendix A).

Eighty percent (12) strongly or moderately agreed when asked if the virtual museum was easy to use, but only 26% (4) strongly agreed with the statement “I did not need special instructions to use the virtual environment”; 73% (11) strongly agreed they learned to use the virtual environment quickly and the same percentage strongly agreed with the statement “It was easy to learn how to use the virtual environment”; 93% (14) strongly agreed when asked if they considered it was easy to remember how to use the virtual museum, and 86% (13) considered that using the virtual museum did not require great effort (Figure 15).

When asked if they considered the virtual museum to be a complement to their visit to the museum 93% of the participants (14) strongly or moderately agreed, but Kalden slightly disagreed. During the personal interview he was asked to further comment on the issue. Kalden said he noted several differences between the two experiences, but he did not mention which ones. He declared they cannot be complementary experiences and suggested offering the museum visitors a kiosk inside the museum where they can get more information.

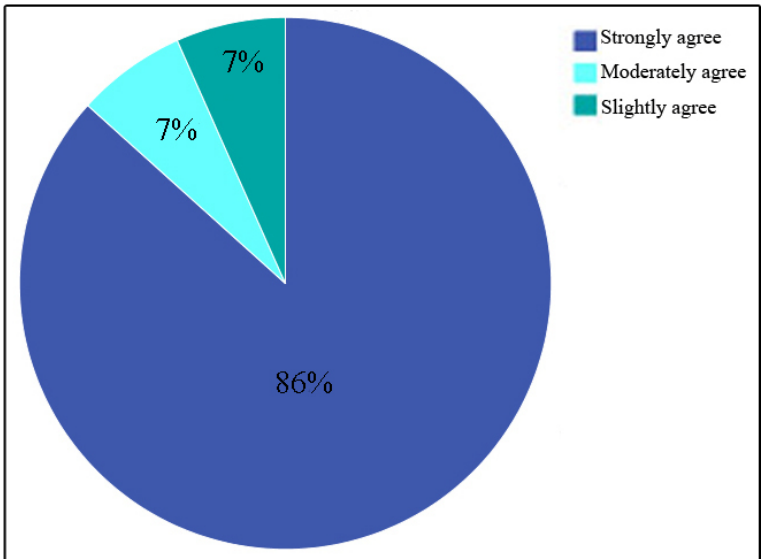

Figure 15. Using the virtual museum does not require great effort.

When asked if the virtual museum is a good alternative for people who cannot go to the museums, 93% of the participants (14) strongly agreed, but Kalden slightly agreed. He did not further clarify his answer during the personal interview.

Participants were asked to mention in one word or short phrase three things that they had liked about the virtual environment and three things that they had disliked. Using Carspecken coding system (1995) their answers were analyzed and grouped into topics. The top three topics that came up when asking the question "Using a word or a short phrase, describe what you did like about the virtual environment" were: ease of use, good option for people who cannot go to the museum, and economic and innovative.

The top three topics that came up when asking the question “Using a word or a short phrase, describe what you did not like about the virtual environment” were: the paintings do not offer the same quality as the real ones; technical issues prevent the correct use of the environment, and mobility in the environment.

Individual Interviews

On the first day of the research participants were given a spreadsheet with their names, the location of the interview room, and the time of the day their personal interview was going to be done so they could be on time. All the participants in the study were individually interviewed the day after they went to the museum and these sessions lasted between 12 and 20 minutes. At the beginning of the interview participants were asked to mention their name and the number they were assigned to identify themselves throughout the investigation. They also were reminded that the interview was being video recorded for transcript purposes, but their identity and the video was not going to be published.

Figure 16. Individual interviews.

Both groups were asked similar questions (see Appendix A, document THindv01) regarding their visit to the museum, and their opinion about offering a virtual museum of that visit. Some other follow up questions arose during the interviews.

Two specific questions were asked to participants to know how the virtual museum could have affected their experience in the museum. Since the main question of this dissertation was to find how a pre-visualization of a virtual museum affects the museum visit, the answers to these two questions were particularly important.

Participants of bothtours group were asked the question, "How did using the virtual museum affect your experience visiting the museum?.”

Participants of onlymuseum group were asked the question "If you had used a virtual tour that had the same paintings, the same spatial distribution, and

the same information before your visit to the museum, how do you think this experience could have affected your visit to the museum?."

Interviews were analyzed and then coded into similar topics. Using two separated Microsoft Word documents for each of the groups, all the transcripts were accommodated in columns containing the question and participants' answers below the question, and then adding another column to annotate the main topic and subtopics that emerged from the responses. The objective of having two separated documents was the comparison between the answers of the two groups regarding the same questions. An external reviewer who is a Spanish native speaker reviewed the transcripts for accuracy and also corroborated the translations of these transcripts to English language. A native English speaker reviewed and approved these translations.

All of the participants of bothtours group answered that using the virtual museum was a beneficial experience because they knew already what they were going to find, and they felt they were more prepared for their visit. Some of the answers were: "the virtual museum gave me weapons to defend myself during the museum visit", "I did know more about the paintings… because I already had all the background" or "It gave me information that I did not know, so when I went to the museum… it was not that difficult to understand the paintings."

Most of the participants felt that having information from a virtual museum and then having information from a museum guide is a good idea. All of the participants declared that they wanted to go to the museum after using the virtual

museum; some of the answers were: “I was curious to see the differences”, “I wanted to see the real paintings and their real size, I wanted to go the museum” or “I wanted to go to the museum because I already knew what the paintings were about, and I wanted to corroborate it.” The main topic of this set of answers was to satisfy their curiosity about the real museum.

When asked about how a pre-visualization of the paintings in a virtual museum could have affected their experience in the museum, participants of onlymuseum group were not as positive as bothtours group. Almost all of them declared that although is a good idea to have more information about the paintings, the idea of previewing them before their visit to the museum could have changed the visual impact. Some of the answers were: “to see the paintings before hand... the distribution, how they were located, it would not have caused the same impact… I would have seen the paintings in a different way, maybe a deeper way, but it would not have been the same” or “maybe it could have affected the way I saw the paintings, the impact… when you see the paintings for the first time you have an impact, and when you have a preview of them… then it is different.” Two participants answered that they would have liked to use the virtual museum first, because that way they could have had more information about the exhibition. The main topic that resulted from this analysis was participants' concern of how using a pre-visualization could affect the visual impact with the real paintings.

Participants of bothtours group were asked to comment about their experience using the virtual museum. Overall all the responses showed a positive reaction to the event; participants mentioned that it was interesting, nice, and fun to use. A couple of them mentioned that the virtual museum offered more information than the real museum. Some participants mentioned that it was a good option for people who can't go to the museums, however almost all of the participants mentioned that "it does not compare to the real experience." Several of them mentioned technical issues they experienced during the usage. One participant mentioned that the information presented in the virtual museum helped her to understand the museum tour. The main three topics that came up on the answers to these questions were: The virtual museum is interesting and nice, it is a good alternate option, and it is not the same as the real museum visit.

Participants of bothtours group were asked to respond in which of the two visits they felt they learned more and why. The objective of this question was to corroborate their answers in the survey THDemo Question 6. The answers to this question were divided: more than half of them answered that they felt they learned more from the virtual museum because "the virtual museum gave a lot of information about the myth", "because there was more information", because "I could read and listen" or "I think I learned more from the virtual because it is better if you read the information of the paintings and you get more from the reading, rather than listening to it from the tour guide." Participants who answered that they learned more from the museum gave these kinds of answers:

“I learned more in the museum because they explain things better”, “there is human interaction” or “I can ask a question and I get an answer, and in the virtual museum you cannot do that.” Two main topics about this question were found: the virtual museum offers more information, but the real museum offers human interaction.

Participants of bothtours group were also asked which one of the two tours they enjoyed the most. All of them answered that they enjoyed their visit to the museum the most because of the direct contact with the paintings and the exhibition room, and because “it is the real thing.”

They were also asked if they would have enjoyed their visit to the museum more if they had not used the virtual museum. All of them said no. Some of the answers were: “In fact I enjoyed it more because I already knew the paintings and the story” or “no, because the virtual museum helped me to understand the exhibition.”

Both groups were asked to talk about their experience visiting the museum. The objective of this question was to analyze and to discover if there were any differences in the responses of the two groups of participants. Almost all the participants declared the museum visit was interesting; a couple of participants from the bothtours group declared they were surprised to see the real size of the paintings, one participant said “you see the real dimension of the paintings and it is even more surprising… the colors, the technique, you can observe them more in detail.” A couple of the participants of bothtours group

commented that they were making mental comparisons between the two tours, and while the museum visit was more enjoyable, the virtual museum offered more information. Festus said that “I liked more the information in the virtual museum, and the fact that in the virtual museum you can stay all the time you want watching a particular piece… in the museum visit, because we had a guide, we had to follow his schedule.” Carlita, who also was part of bothtours group declared that “it was a complete experience because now you see it… you are there… in the virtual museum you can only imagine things, but in the physical one you are there.”

Participants of onlymuseum group also found the museum visit interesting, most of them talked about the particular shape of the exhibition room. Some of them also mentioned that the explanation of the museum guide was interesting and interactive, and overall their experience was a positive one.

Both groups were asked to give their opinion about offering a virtual museum. All of the participants of bothtours group had positive opinions about the idea, most of the participants declared the virtual museum is a good idea for people who cannot attend museums because of distance or lack of time; some of them said is a good complement to the museum visit and people can have access to more information and be more prepared before their visit to the museum; other participant mentioned that they could see museums in other countries using virtual museums. Another one mentioned that virtual museums are like “movie trailers… you see them and then you want to go see the movie.”

The only neutral or negative opinions came from participants of onlymuseum group. Carol declared: “I prefer to go to the museum; I don’t think it is the same to see the paintings through a screen than seeing them with their real dimensions.” Mason said that “if I would have taken the virtual museum tour… maybe that could have affected my decision about going to the museum… if there was nothing interesting about what I saw in the virtual I might say ‘why should I go to the museum now?’ but if I see a panting that interests me, with more reason I would go to the museum.” Joshua said “It is useful but it takes away the intention of going to the museum, it is like if you see the Mona Lisa at the Louvre and then you see it again in your computer, it is not the same…”

Four of the participants of onlymuseum group declared that the virtual museum is a good idea but it should be used after the visit to the museum; one of the reasons was: “if you had any doubts after your visit to the museum, or if you arrived late, the virtual museum could help you in solving those doubts.”

Emma said that a virtual museum is a good idea especially used for temporary exhibitions because “if for X or Y reason you cannot make it to the museum, you cannot go, you miss the dates, or the time limits you, and you really want to see those exhibitions, the only other option is using a virtual museum.”

Participants of both groups were asked to mention some of the advantages of offering a virtual museum. The main topic of the answers was the money: the majority of the participants declared that virtual museums are free, or

they would be relatively cheaper than visiting a museum, considering transportation, entrance tickets, meals, etc. The second topic of their answers was the time: some of them declared that the virtual museum is open 24 hours a day, and people can see the exhibitions at their own pace, there are no schedules. The third topic was the ease of access to information: some participants noted that a virtual museum can offer more information of an exhibition, and people can also use external links or the internet to look for more information if they have any doubts about what they are reading or listening to; some mentioned that in museums sometimes there are not guides available to give people information about the works. Another topic that surfaced was the comfort: people can have access to museums from their houses. One participant observed that it is an excellent idea for people with disabilities, he mentioned his mother as an example, and that it would be a good alternative for her to use virtual museums.

Finally all the participants of this study were asked to answer the question "In what ways can a virtual museum and a museum visit complement each other?." Almost all the answers suggested that the virtual museum should offer more information about the exhibitions; therefore people can use the virtual museum, have an idea about the exhibitions, and then go to the museum. Some of the answers were: "if you use the virtual museum… then you go to the museum and you have an idea more or less, and understand some things that you could have not understood if you hadn't used the virtual museum"; "using the

virtual museum could help you a lot when you go to the museum because you already know what paintings are on exhibit, which ones you found more intriguing, which ones you want to see more in depth"; "for me, it would be better to first use the virtual museum to have an idea about what you are going to see, and then go to the museum" and "the virtual museum complements the museum visit very well because of all the information it contains… some tour guides cannot memorize all the information and you can have it in the virtual museum."

Analysis of the Discourse in the Museum Visit

As mentioned before, at different hours both groups had a museum visit on the second day of the research. The tour guide did not have knowledge about which one of the groups had used the virtual museum. Due to a schedule conflict the guide was not the guide who participated in the pilot study and provided and approved the information that generated the script for the virtual environment. Two days before the museum visits, the guide was given the script so he could be familiar with the content. Participants of the onlymuseum group had the first visit and it lasted 35 minutes and 18 seconds. Bothtours group visit lasted 38 minutes and 12 seconds. Bales' Social Interaction System was used to analyze the interactions of both groups with the museum guide and among themselves. Several field annotations about the two tours were generated, the transcript follows:

Field Annotations from Bothtours Group

As soon as the participants entered to the exhibition tour, two people commented: “It is the same as the virtual museum!” Almost all of the participants were looking to their surroundings and the paintings. The tour guide had to ask for their attention to start the tour.

During the introductory explanation most of the participants were paying attention to him, but three of them started wandering around the room to see the paintings and then started commenting about them forming a small group. Two participants asked questions to the guide about the explanation he was giving. Then the group moved to the first painting, they listened attentively to the explanation and then went to see the next painting. On this particular painting, the tour guide gave them a completely different explanation than the one they had gotten from the virtual museum, in fact it contradicted it. Some of the participants showed disbelief and looked at each other in surprise. Some attempted to give an opinion and two of them seemed to stop listening to the guide and started wandering and looking at other paintings.

When they moved to the next painting, the tour guide asked a question about the Minotaur horns, several of the participants started talking at the same time about this issue, until Anna took control and started explaining her point of view about the painting. She also repeated some of the information that was given to her in the virtual museum. The tour guide tried to continue with the explanation and was interrupted by Jacob giving his opinion about the painting;

Festus joined the discussion, and then some others joined and even started pointing at the painting to show the guide what they were talking about.

Figure 17. Bothtours group at the museum visit.

The group continued with the museum visit and the tour guide did an interactive activity about the movements of the Minotaur in a particular painting. He asked two participants to reenact the movements of the Minotaur. Almost all of the participants were expressing their opinion, laughing or pointing at the painting. Anna asked about the composition of the painting mentioning some information she got from the virtual museum but the tour guide gave them a different explanation; then participant Festus mentioned that the two paintings that they were discussing had to be read from left to right. This information was contained the virtual museum. Again the tour guide contradicted this information, and some participants showed surprise and disbelief, Festus continued questioning the guide about the painting but the tour guide ignored him and

continued with the activity. All of them paid attention to it and were again smiling, laughing and commenting.

The guide took them to the interactive kiosk to see several videos about the paintings and showed them the model the artist used to portrait the Minotaur. All of them showed surprise when they saw the pictures of the model. A couple of them started commenting about the videos.

Figure 18. Using the interactive kiosk at the museum.

While the guide was talking to them, Karissa continued playing with the kiosk, and then all of them started paying attention to the videos. After that, the group continued with the tour, but three participants stopped paying attention to the guide and went ahead to watch the rest of the paintings. The guide did not explain all the paintings. When the visit ended the guide asked them if they had more questions. Three questions were asked about Flores' technique, his exhibitions and more information about the museum. Participants stayed another

five minutes observing and commenting about the paintings without the presence of the tour guide.

Field Annotations from Onlymuseum Group

The first four minutes of the museum visit none of the participants asked any questions. All of them were passively listening to the tour guide, none of them attempted to see the paintings as their attention was focused only on him. When the guide asked specific questions some participants attempted to answer them. During the tour, one participant asked the guide if he was going to explain one of the paintings that they had already passed and that they hadn't stopped to analyze. The tour guide gave a small explanation of the painting and there were no following questions from the group. The group continued with the tour and then few minutes after, the guide did an interactive activity regarding the movements of the Minotaur depicted in one of the paintings. He asked two participants to recreate the movements. The majority of the participants were smiling or laughing but did not express any comment. Again, all their attention was focused on the tour guide and the two participants. When he asked questions about the paintings, some of them attempted to answer them; some others focused their attention on the particular painting the guide was referring to.

Figure 19. Onlymuseum group at the museum.

The tour continued and few of them started to observe other paintings while the majority continued with the tour guide. They stopped at the interactive kiosk where the guide explained more about the paintings using its information. He showed them the model Leopoldo Flores used for the Minotaur and all of the participants showed surprise and interest. Several out-loud expressions like “ahhh!” or “ohh!” were heard. They spent several minutes analyzing the information at the kiosk, and then they continued with the tour. Again, all of them listened passively to the explanation of the paintings. No questions were asked. The tour guide did not explain all of the paintings.

On the last painting, only one student asked one question. The tour guide attempted to ask questions about the paintings and only a few students responded. At the end of the tour, the guide asked the participants if they had any questions about the exhibition, only two questions were asked: one about

one of the paintings and the other about Flores' age. The tour guide returned them to the kiosk to see more information; they spent 6 more minutes at it, and then the visit finished and all of the participants left the room with the tour guide.

Observation Categories for the Museum Visits

The field notes and the video taken from both museum visits were analyzed and the overall interaction of the two groups with the tour guide was coded using Bales' 12 observation categories (Bales, 1950). Using a table to accommodate these categories and the number assigned to each of the participants, it was possible to have a measurement of the overall museum activity (Table 2 and 3).

Table 2

Occurrences of Bothtours Group

Participant No.	1	3	5	7	9	11	13	15	17	21	23	25	27	29	31	Number of Occurrences
1 Shows Solidarity																0
2 Shows Tension Release	13	13	13	13	13	13	13	12	12	12	13	12	12	13	12	189
3 Agrees	4	4	7	3	8	5	5	3	3	3	4	3	3	5	3	63
4 Gives Suggestion			1			1										2
5 Gives Opinion	4	7	1	4	7	3	4	1		1		1	1	1		35
6 Gives Orientation	4	5	1	1	2	3	3		1							20
7 Asks for Orientation	3	1	2	1	1	1			1							10
8 Asks for Opinion																0
9 Asks for Suggestion																0
10 Disagrees	2	1			4		1						1	1		10
11 Shows Tension																0
12 Shows Antagonism																0

The video recording of the two visits was seen several times, each of them following a specific participant; every time the participant expressed certain behavior (verbally or non-verbally), it was reported on the table annotating the

specific time at what it had occurred; then all these activities or “occurrences” as Bales defined them were accounted.

Table 3

Occurrences of Onlymuseum Group

Participant No.	2	4	6	8	10	12	22	24	26	28	30	32	Number of occurrences
1 Shows Solidarity										1		1	2
2 Shows Tension Release	5	4	4	5	4	6	6	5	7	5	4	7	62
3 Agrees	2	1	3	3	3	1	4	1	3	4	1	9	35
4 Gives Suggestion													0
5 Gives Opinion		2				1	1	1	4	5		7	21
6 Gives Orientation													0
7 Asks for Orientation	3					2			2	1			8
8 Asks for Opinion													0
9 Asks for Suggestion													0
10 Disagrees													0
11 Shows Tension													0
12 Shows Antagonism													0

There are several differences between the two groups that are being shown on the tables. The most noticeable one is regarding category No. 2 "*Shows Tension Release*, jokes, laughs, shows satisfaction." Bales included expressions of cheerfulness, satisfaction, gratification, enjoyment, pleasure, contentment or the like in this category. Bothtours Group presented 189 occurrences in this category and onlymuseum Group showed 62. Although there is no evidence this difference is related to the virtual environment usage and most likely could be related to the groups’ dynamics and the relationship among the participants, the difference in the number of occurrences is substantial. This category is included in the social-emotional area and it can be classified as a positive reaction.

Participants from onlymuseum group presented two occurrences included in the category “Shows solidarity.” These occurrences were presented after two participants reenacted the movements of the Minotaur. Joshua and Mason praised them and told them “you did a good job!” and patted them on the back.

Another significant difference is presented in the category No. 3 "*Agrees*, shows passive acceptance, understands, concurs, complies." Bales defined this category as any action that shows accord, concurrence or assent about facts. Bothtours group almost doubled the number of occurrences with 63, compared to onlymuseum Group that presented 35. As it was described in the field notes, most of the times participants from onlymuseum group were inactive, not even agreeing with gestures, while participants from bothtours group showed their agreement with gestures or comments about the exhibition.

Regarding the 5th category "*Gives opinion*, evaluation, analysis, expresses feeling, wish" bothtours group presented 35 occurrences and onlymuseum group presented 21. This category was coded measuring all the times participants were responding to a direct question from the tour guide, or were commenting among themselves.

Another significant difference between the two groups was presented in Category No. 6 "*Gives orientation*, information, repeats, clarifies, confirms." Bothtours group presented 20 occurrences and onlymuseum group presented zero. Bales included in this category all the statements that convey knowledge in a context where a person wants to give information without being asked to. In

this study this category was coded measuring all the times participants were giving their opinion without being asked, including interrupting the tour guide to clarify his information, or when they stayed apart from the main group to give information to other participants about the paintings or the tour.

Bothtours group presented ten occurrences on category No. 7 "*Asks for orientation*, information, repetition, confirmation" and onlymuseum group presented eight occurrences. Bales enclosed in this category all the questions requesting a factual and descriptive type of answer. This category was coded adding an occurrence every time a participant asked a direct question to the guide.

Another area that showed differences between the two groups was No. 10 "*Disagrees*, shows passive rejection, formality, withholds help." Bothtours group presented ten occurrences and onlymuseum Group presented zero. Bales included in this category any act that rejects another person's statement of information, opinion, or suggestion. This category was coded annotating an occurrence every time a participant showed disagreement to the tour guide either verbally or with body expressions.

Group Interview

On the last day of the data collection, both groups were asked to attend a joint group interview to corroborate findings. Participants were provided with a detailed explanation about the objectives of research process and the preliminary

findings, and were encouraged to have an informal discussion about their perception and opinions concerning the study. This activity was also video recorded and it lasted 15 minutes.

Figure 20. Group interview.

Both groups were asked to discuss their perception about using a virtual representation of the museum previous to their museum visit. Participants from bothtours group voiced comments such as: “the virtual museum was very helpful because it made me want to go to the museum, and I could understand everything better” or “virtual visits give you an incentive to go to the museum.” Mason from onlymuseum group expressed his opinion saying it would be better to take the virtual museum after the museum visit. Ruth –also from onlymuseum group- commented: “it is funny, because at the end of the visit we had the chance to check the kiosk with the videos, and no one stayed… if they don’t give you the virtual tour, you don’t have the incentive to look for it.”

Participants from bothtours group were also asked to reflect having two different explanations about the same exhibition, one from the virtual museum and the other one from the tour guide, and to meditate if this situation gave them an advantage over participants from onlymuseum group. Almost all of them voiced their agreement. Emerson explained: “definitely yes, because in the virtual we were given an explanation about the composition of the paintings and how to read them… we could understand them better, and this is something the other group did not have.” Karissa expressed: “during the virtual visit I was anxious because I couldn’t see some perspectives that I wanted to see, so when I went to the museum I said ‘I want to stand over there to see how it looks’, so I think it gives you some advantages.” Festus voiced: “both have pros and cons, but I think they complement each other very well in terms of visualization and information, because both were very different, but together gave you a complete idea.”

Summary

In this chapter, the results from the data collection were presented. Comparative analysis of knowledge acquisition between groups was exhibited. Perception and satisfaction in the museum visit was analyzed. Opinions about usability of the virtual museum were showed. The coding of the individual interviews was introduced, the analysis of the discourse in both museum visits was presented, and the four main questions of this dissertation were answered.

Next chapter presents the final discussion about the findings of this document and offers a conclusion to this investigation.

CHAPTER 5

DISCUSSION AND MAJOR FINDINGS

This chapter presents the major findings of this study and will provide answers to the research questions presented in Chapter 1. It also provides additional thoughts about the research, discuss future research directions, and offer conclusions of the investigation.

Major Findings

Analyzing the responses to all the instruments, individual interviews, and observational videos generated from the data collected during the four days of research, several topics emerged. The following primary emergent topics will be discussed:

The first one has to do with knowledge acquisition while using a virtual environment. Although at this time a comparison about generating knowledge between a virtual museum and a real museum tour cannot be made (see further in this chapter, research question and sub-questions section), from the pilot study

and this research it can be stated that participants to this study acquired some kind of knowledge from the virtual museum alone. This knowledge helped them to understand and feel more confident in the museum visit because they already knew “the paintings and the story behind them.” Results of the pre and post-tests administrated to participants during the pilot study and this investigation showed an increase in the questions answered correctly after they used the virtual museum. In the pilot study, participants went from answering a median of 27% questions answered correctly, to a median of 86% of questions answered correctly after they used the virtual environment. During this study, participants went from answering a median of 27% questions answered correctly, to a median of 67% of questions answered correctly after using the virtual museum. Also, during the personal interviews all the participants agreed that they learned something from the virtual museum, with two participants even declaring that they learned more from the virtual environment than from the museum visit.

The second topic that emerged is the difference in opinions between bothtours group and onlymuseum group about offering a virtual museum prior to the museum visit, which was expressed during the individual and the group interviews. Participants from bothtours group agreed that it is more helpful to offer a virtual tour of the museum before the museum visit and that using a virtual representation geared them up to their museum tour. The majority of participants from onlymuseum group felt that it was best to offer a virtual museum after the real visit, so the visual impact with the pieces did not get affected. Two

participants of onlymuseum group also declared that if people leave the museum with any doubts, they could consult the virtual museum.

The third topic that arose from this research was encountered during participants' visit to the museum, and it indicates that there are an increased number of what Bales (1950) called "occurrences" in the museum from the group of participants that had previously used the virtual environment.

Although there are some significant differences (see Table 4) between the two groups in categories such as "shows tension release" and "agrees", according to Bales these could be the result of the group dynamics, but some others might be the result of the previsualization of the museum visit (Consult Chapter 2, discourse analysis section).

Table 4

Differences in Occurrences

Category	BothTours group	OnlyMuseum group
Shows tension release	189	62
Agrees	63	35
Gives opinion	35	21
Gives orientation	20	0
Asks for orientation	10	8
Disagrees	10	0

These particular occurrences show a significant difference in verbal and non-verbal discourse in the participants of both groups, and it is related to the information given to them by the tour guide about the paintings or the artist. Bales included the categories “Gives orientation” and “asks for orientation” in a sub-classification named “Problems of orientation.” Bothtours group scored 30 occurrences from these two categories and onlymuseum group presented 8.

According to Bales, groups that present occurrences in these categories are either attempting to answer questions expressed for other member of the group, or attempting to give information or clarify a topic. It is particularly important to pay attention to the “gives orientation” category and the difference in occurrences between the two groups: 20 from bothtours group vs. zero from onlymuseum group. While participants from bothtours group were attempting to answer, gave information, orientation, and either confirmed or disagreed with the tour guide, participants from onlymuseum group did not attempt any of those behaviors. Remembering, this category was coded measuring all the times participants were giving their opinion without being asked, including interrupting the tour guide to clarify his information, or when they stayed apart from the main group to give information to other participants about the paintings or the tour.

Another difference in occurrences is again presented in the number of those contained in category number 10 “Disagrees.” Bothtours group presented ten occurrences while onlymuseum group presented zero. Bales included this category in the expressive-integrative social emotional area, defined as an

expression of emotional tensions, solidarity, identification with the group, and sense of mutual responsibility. During the museum visit, participants from bothtours group expressed either verbally or non-verbally their disagreement to statements about the paintings or the Minotaur myth made by the tour guide.

Table 5 shows the total number of differences in individual occurrences presented by the participants in both groups. In some cases participants from bothtours group show two or three times the number of occurrences compared to participants in onlymuseum group.

Table 5

Individual Occurrences

BothTours Group Participant No.	1	3	5	7	9	11	13	15	17	21	23	25	27	29	31
Total occurrences	30	31	25	22	35	26	26	16	17	16	17	16	17	20	15

OnlyMuseum Group Participant No.	2	4	6	8	10	12	22	24	26	28	30	32
Total occurrences	10	7	7	8	7	10	11	7	16	16	5	24

A fourth theme originated from this research is that even though participants see many advantages of using a virtual museum (see table 6), all participants expressed that a virtual tour will never compare to the real experience of visiting museums. During the analysis of the individual interviews, multiple comments such as “it does not compare to the real experience” were encountered. However, all the participants in bothtours group agreed that using a virtual museum did not prevent them from wanting to go to the museum; on the

contrary, their curiosity was triggered to see “the real thing” because they “already had the information… understood everything better, and wanted to complete the experience with the museum visit.” Museums like the Museum of Modern Art (MoMA) are well aware of this virtual outreach, with his director declaring that “online engagement is absolutely driving people to the museum” (Gopnik, 2011).

Table 6

Advantages of Using a Virtual Museum

Accessibility to places that otherwise would be difficult to attend because of distance issues
Having a previsualization about what they are going to find in the museum, therefore having more information and being more prepared for their museum visit
Saving time by using the virtual museum at their homes
Seeing the exhibition at their own pace without following a tour guide
It is a good option for temporary exhibitions
It is a good option for people with disabilities
Saving money

A last major emergent topic that came up had to do with the virtual museum itself. While nearly all participants stated it is easy and fun to use, and that they did not require special instructions to learn how to utilize it, several

comments about the quality of the graphics or difficulty of movements inside the environment were encountered. In an era where people are constantly bombarded with new technologies seeking their attention, and more and more users are keeping up with the most up-to-date online graphic environments, a good quality virtual museum that is easy to use seems a must-offer experience.

Another issue that participants mentioned continuously throughout the personal interviews was the fact that the virtual museum lacks human interaction which sometimes can be perceived as a necessity during a museum visit. The fact that the Leopoldo Flores virtual museum is a one-person closed system that cannot share or integrate information from social networks can be perceived as a disadvantage in these days where online sharing is the trend to achieve. Lacking a good internet connection can also be a factor for lack of enjoyment of the virtual environment, as it was attested during this investigation (see further on this Chapter).

Research Question and Sub-questions

This section will present a summary of responses to the research question and sub-questions (See Chapters One and Three). Considering the data presented in Chapter 4, it is possible to provide answers to them. This section discusses the research problem and then each of the sub-questions:

In what ways does a pre-visualization of a virtual museum affect the museum experience?

Overall, participants who experienced the virtual museum concurred that using it was a positive experience that prepared them to go to the real museum because they knew already what they were going to find. All of them wanted to go to the museum after using the virtual one and none of them felt they have had enough with the virtual tour. They wanted to see the real exhibition because it triggered their curiosity. Most of the participants agreed that the information contained in the virtual tour helped them to interpret and have a deeper understanding of the paintings. All the participants from bothtours group also agreed the information offered at the virtual museum complemented the one presented at the museum. They also realized the benefits a virtual tour offers, including saving time and money, and declared it is a good alternative for people who cannot attend those places.

The group of participants who experienced the virtual museum presented several occurrences (Bales, 1950) in the categories of 'gives opinion, gives orientation, and disagrees' either expressing their own opinion about the exhibition, informing and orienting their peers, or disagreeing with the tour guide when they believed he was giving them a wrong information.

In what ways visitors discourse is affected by previously experiencing a self-guided virtual tour of the same exhibition?

Results show that most of the participants who experienced the virtual museum exhibited an increased activity during their museum visit, either agreeing, being more participative, concurring and showing acceptance, asking

questions, or even giving their opinion and analysis, disagreeing with the guide and showing passive rejection.

Can users of a self-guided virtual tour show gains in knowledge acquisition?

Results show that participants who experienced the virtual museum showed an increase on their correct answers to the knowledge acquisition questionnaires, going from 27% answers responded correctly in the pre-test, to 67% of correct answers after the virtual museum usage. Also almost all of them strongly or moderately agreed with the statement “I think I learned something from the virtual environment”, with two of them even declaring having learned more from the virtual museum than the museum visit.

Can visitors who use a self-guided virtual tour and then attend the real museum tour show gains on knowledge acquisition, vs. those visitors experiencing only a museum tour?

This answer will remain unanswered since it was impossible to make a comparison with both groups pertaining knowledge gains. As it will be mentioned later in this Chapter, the lack of a versed tour guide during the study impacted the visit at the museum, which made the knowledge acquisition in this phase potentially flawed for the purposes of this study, and impossible to compare between the two groups.

Lessons Learned

Almost every research process will present unforeseen events, and this one was not the exception. During the pilot study the researcher had help from a Mexican graduate student and a colleague from UAEM in Mexico who helped to coordinate the visits to the museums, who got the permits for the access to computer labs, and who made sure that the environment was running correctly in the computers that were going to be used during the data collection. During the course of this study the researcher had to coordinate everything from afar, which lead to several issues not functioning properly throughout the data collection.

The methodology presented in Chapter 3 allowed this research to deliver answers to the research questions, the triangulation of methods supplied cross validation, and the instruments permitted an appropriate data collection and analysis. Coding the individual interviews using Carspecken system (1995) provided insightful thoughts of the participants' perceptions about the virtual environment and the museum tour, and allowed the researcher to group the conversations in different categories. The group interview on the last day of the data collection confirmed the findings achieving credibility which was one of the four issues of trustworthiness mentioned in Chapter 3. The different instruments provided answers to usability and attitudes towards the virtual visit and the museum tour. The analysis and coding of the observations using Bales' interaction system (1950) offered an effective classification of the verbal and non-verbal discourse presented by participants in the museum visits, and the

questionnaires used to analyze the experience in the virtual environment and the museum visit allowed the researcher to demonstrate and to corroborate knowledge acquisition findings.

After covering major findings derived from the data analysis, it is important to address two major issues that affected the data collection process and might have affected the overall result of the study. The first dealt with the virtual environment usage phase. During the planning of the visit to Mexico to collect the data, the researcher was promised to have a computer room equipped with the proper technology to run the virtual museum. During the pilot study no technical issues concerning the virtual environment usage were encountered, so it was assumed that this second time it was going to be similar. However, in this occasion the equipment assigned for the virtual museum did not have the same specifications than the one used during the pilot. A room with PCs was assigned but it was found that the virtual museum was impossible to function because of the lack of an adequate video card in the machines that would support the graphics. The person responsible of making the decision of assigning other machines was out of town, and because of the amount of time considered for this activity, and the impossibility to reschedule other activities such as the museum visit, a small room used for video editing had to be used that day by the participants of bothtours group. Unfortunately, this room was an open lab with college students circulating all the time, which reduced privacy to the experience. Also, the five machines assigned were not equipped with headphones (see figure

21) therefore, during the virtual environment usage participants were able to listen to other participants' machines, making it difficult for them to pay attention to the sound explanation.

Figure 21. Using the virtual environment.

Besides that, several internet shortages were presented throughout the entire day, resulting on the paintings or the information not displaying properly, and making some of the participants to feel disoriented, to skip paintings, or even to feel annoyed with the experience, as they expressed it during the personal interviews.

This issue might have affected the overall perception and knowledge acquisition participants had from the virtual environment. Comparing the reactions presented in the pilot study to the virtual environment with the reactions obtained during this data collection, some important differences in perception were encountered, with the most significant in their opinion about learning from

the virtual environment. In the pilot study almost all of the participants (93%) declared they learned something from the virtual environment, compared to 60% from this study.

A second major issue was presented during the museum tours. As it was mentioned before, the tour guide that facilitated the visits in the museum was not the same one who reviewed and approved the information contained in the virtual environment during the pilot study. For personal reasons she could not participate in this research study, therefore the museum director assigned another guide.

The guide was given the script of the virtual environment two days before the museum visits so he could study it and could become familiar with the content, but unfortunately, as it was witnessed during both visits, he ignored it and gave the participants information that was different to the one presented in the virtual museum. While in the pilot study the tour guide focused in the Minotaur myth and the technique of the paintings reinforcing the information contained in the virtual environment, during this data collection phase the new guide concentrated more in the events that were happening in the city and the year when the paintings were made, sometimes even contradicting the information contained in the virtual museum.

Although he gave the participants new information about the artist and the model the artist used to paint the Minotaur, the tour guide never reinforced the information contained in the virtual environment. In both visits he mentioned that

“you would think that these paintings have to do with the Minotaur myth, but that is completely untrue.” This issue prevented the learning outcomes comparison between the two groups and precluded the researcher of answering one of the sub questions of this study.

Another lesson learned and recommendation for other researchers is always to bring help. Unlike the pilot study, the researcher had to do everything with no help, from taking pictures to video film the museum visits, from interviewing all the participants to reviewing the instruments for possible follow up questions. It would have been less stressful and easier if someone else was there to share the work.

Finally, if in the future this research gets replicated with the same methodology and instruments, it is suggested to consider more days for the data collection process, especially if a bigger number of participants are going to take part in the research. This will allow more time to analyze the results of the different instruments, to have more personal interview time for additional prolonged engagement with the participants, and if necessary, to formulate follow up questions if they arise. It will also provide more time to solve unforeseen issues, like the one presented in this research with the computing equipment.

Directions for Future Research

One of the primary issues to build on is to further examine the knowledge acquired in the virtual museum and in the museum tour. If it is demonstrated that

people can gain similar knowledge from both experiences it will strengthen the argument of using virtual environments for learning. The methodology presented in this document might be used not only for different types of museums but for other types of learning environments such as classrooms, libraries or virtual field trips.

A second issue that requires further exploration is if culture plays a role on the results obtained from this research. Both, the pilot and this study were performed with Mexican participants, who belong to a different culture from the American one. If this research is replicated using undergraduate American students from a college in United States using an exhibition from an American artist, would the results be similar to the ones presented in this document?

Another topic to further research on is to analyze more in depth the differences in perception about a virtual environment between two groups of participants, one of which has used a previous virtual tour.

Another theme to explore is the assessment of a collaborative virtual museum for learning. It was noted during the course of this research that several participants 'missed' the human interaction aspect in the virtual museum. In what ways a collaborative virtual museum that supports multiple users interacting at the same time would affect their experience in the museum? Can they generate the same knowledge than participants experiencing a one-user environment? What would be the differences in usability and satisfaction between a multi user

virtual museum and a one-user virtual environment? These questions require further research.

A last suggested issue to further research on is using virtual museums for promotional purposes. As it was attested in this research, all the participants who experienced the virtual visit wanted to go the museum afterwards. Maybe virtual museums can make a big contribution to the public image of the museum making their collections accessible for a world-wide public, and museums can use these virtual spaces as the perfect global promotion for their sites.

Conclusion

Museums have an important role to play in education and society, and visiting museum exhibitions is a personal and individual experience that is sometimes shaped by interactions with others. People are acquiring knowledge in museums and this is a free choice learning experience determined by the way they interpret the pieces and the space around them. This learning process is influenced by their beliefs, their background, their education, and their environment. It is also molded by the distribution of the pieces, the colors of the walls, the space, the illumination, and the information they receive in the museum. Visiting these places is an experience that goes beyond observing the pieces and their distribution. It is an experience that includes the work of curators, educators and communicators. They design the space where the pieces are going to be displayed, deciding the use of specific colors, the way the

pieces are accommodated. All of these decisions have an intention, and now the goal seems to be to make those visits accessible to more and more people. With the introduction of the internet and online virtual environments to our lives, researchers and educators can have now an important ally to solve this issue. Creating virtual museum tours present the public with the power to perform different engaging activities that they might not be able to experience in physical museums.

Virtual museums offer visitors with the ability to access places and information that because of distance or money, they might never experience. If researchers and educators attempt to prove that people are not only using and enjoying these virtual places, but they are also generating knowledge, this will continue to help the discussion in favor of using these environments for learning.

The main characteristic of virtual museums is that they offer the visitor the opportunity to engage in different activities, from “touching” different objects inside the environment to reading the information about them, or even creating their own exhibitions. Virtual museums offer much more than a solid space with bricks, glass and mortar. They can provide with one click a new experience in which users can explore the web for more shareable and insightful information. Research in virtual museums is a new field of study and while there have been some research projects that seek to deliver museums’ content online, not many have assessed this effort, and using mixed methods to evaluate the effectiveness

of virtual museums seems to be an adequate solution for an almost vacant research field.

Figure 22. Museums as places for learning.

This study has attempted to show that experiencing a virtual museum can be similar to the experience in physical museum visits, not only engaging participants to go to the museum, but sometimes even offering a more functional way to deliver content. Results of this research evidence that using a virtual museum creates a positive impact in users before, during, and after the museum visit, and that it can be a good alternative, not only for educational, but for promotional and recreational and purposes.

APPENDIX A

INSTRUMENTS

University of North Texas
Research in Museums and Educational 3D Virtual Environments (THDemo) Internet Usage

Name _____ Number _____

Please select/write the right answer:

Sex: Male Female

Age: _____

1. I've been using computer software for:

a) Less than a year
b) More than a year, but less than 2 years
c) More than 2 years, but less than 3 years
d) 3 years or more

2. I've been using the internet for:

a) Less than a year
b) More than a year but less than 2 years
c) More than 2 years but less than 3 years
d) 3 years or more

Please select the option which bests describe the frequency of your personal technology usage.

3. I make use of the following technologies:

	Never	1-2 days per week	3-4 days per week	Daily
Office production tools (MS word, excel, power point)				
Computer				
E-mail				
Text/instant messaging				
Social network sites such as Myspace or Facebook				
Read blogs				
Write blogs				
I maintain my personal website				
I play online games, such as World of Warcraft, Diablo, Age of Empires, etc)				
Create my own pod casts				

University of North Texas
Research in Museums and Educational 3D Virtual Environments
(THSatV) Virtual tour satisfaction

Name _____ Number _____

Please select the option which bests describe your opinion about the virtual tour

	Strongly agree	Moderately agree	Slightly agree	Slightly disagree	Moderately disagree	Strongly disagree
1. Using the virtual museum is captivating						
2. Using the virtual museum is enjoyable						
3. Using the virtual museum is confusing						
4. Using the virtual museum is frustrating						
5. Using the virtual museum is fun						
6. I think I learned something from my experience using the virtual museum						
7. The narrative in the virtual museum helped me to learn more about the artist and the pieces.						
8. I feel I would have learned more by exploring the virtual museum without the need to follow a narrative						
9. My experience with the virtual museum encouraged me to seek more information about the artists/pieces in the tour						
10. I want to learn more about the artists/pieces of the tour as a result of my experience using the virtual museum						
11. The virtual museum offers enough information about the artist/pieces of the collection						
12. I would like to explore other collections using the virtual museum						
13. The virtual museum is easy to use						
14. I did not need special instructions to use the virtual museum						
15. I learned how to use the virtual museum quickly						
16. It was easy to learn how to use the virtual museum						
17. Is easy to remember how to use the virtual museum						
18.Using the virtual museum is effortless						
19. I think there is a lack of instructions of how to use the virtual museum						

	Strongly agree	Moderately agree	Slightly agree	Slightly disagree	Moderately disagree	Strongly disagree
20. The virtual museum is a good alternative for those who cannot go to the museums						
21. The virtual museum is a complement for my visit to the museum						

Using one word, describe 3 things you did like about the virtual museum

Using one word, describe 3 things you did not like about the virtual museum

Would you be willing to sit for an interview about your experience with the virtual museum? Yes No
If your answer was NO, can you give us a reason?
Thank you.

University of North Texas
Research in Museums and Educational 3D Virtual Environments
(MV-Q01) Museum tour satisfaction
Name _____ Number _____

Please select the option which bests describe your opinion about the tour in the museum

	Strongly agree	Moderately agree	Slightly agree	Slightly disagree	Moderately disagree	Strongly disagree
1. Visiting the museum was captivating						
2. Visiting the museum was enjoyable						
3. Visiting the museum was confusing						
4. Visiting the museum was frustrating						
5. Visiting the museum was fun						
6. I think I learned something from my experience visiting the museum						
7. The narrative in the tour in the museum helped me to learn more about the artist and the pieces.						
8. I feel I would have learned more in the museum without the need to follow the guided tour						
9. My experience in the museum encouraged me to seek more information about the artists/pieces in the tour						
10. I want to learn more about the artists/pieces of the tour as a result of my experience visiting the museum						
11. The museum tour offers enough information about the artist/pieces of the collection						
12. I would like to explore other collections in the museum						

Using one word or short phrase, describe 3 things you did like about your visit to the museum

Using one word or short phrase, describe 3 things you did not like about your visit to the museum

Thank you.

University of North Texas
Research in Museums and Educational 3D Virtual Environments
(THindv01) Personal interview

Experience
Tell me about your experience using the virtual tour (follow-up questions, if any)
Tell me about your experience visiting the museum (follow-up questions, if any)

- Tell me about the differences you found between the two tours?
- What are the similarities between the two tours?

What do you think are the advantages of using a guided tour in a museum?
What do you think are the disadvantages of using a guided tour in a museum?
How did using the virtual museum affect your experience visiting the museum?

Knowledge
What did you learn in the virtual environment?
What did you learn in the museum visit?
Do you think you can learn while visiting museums? Why?
In which one of the two tours you think you learned the most? Why?
Which one of the two tours did you enjoy the most? Why?
Do you think you could have enjoyed more your visit to the museum if you didn't have the experience with the virtual museum? Elaborate

Usability:
If you could improve the virtual tour, what would you include?
If you could improve the tour in the museum, what would you include?

Advantages and disadvantages
What is your opinion about offering a virtual tour of a museum?
What are the advantages of using a virtual museum over visiting a museum?
What are the disadvantages of using a virtual museum over visiting a museum?
In what ways a virtual museum tour and a real museum tour can complement each other?

For group 2
If you had used a virtual tour that had the same paintings, the same spatial distribution, and the same information before your visit to the museum, how do you think this experience could have affected your visit to the museum?".

University of North Texas
Research in Museums and Educational 3D Virtual Environments
Group interview

Before asking questions, explain the research objectives

Tell me about your experience this week

What did you learn about your experience?

What do you think about having a pre visualization of what you are going to encounter in a museum exhibition?

Which one do you think is better: Having previous knowledge about the exhibition or not having it? Why?

In the future, what steps will you take before going to a museum?

What are the advantages of a virtual museum?

What are the disadvantages of a virtual museum?

Tell me what you learned in the virtual museum that you did not learn in the real one?

What advantages do you think you have over the group that did not experience the virtual museum?

Discuss with both groups the order in which they would use the virtual environment, before or after the physical tour?

Corroborate findings

University of North Texas
Investigación en "Museos y ambientes educativos virtuales en 3D"
(THprep01) General Knowledge

Name _____ Number _____
Choose the right answer.

1. What is Leopoldo Flores' line of work?

☐ Sculpture and painting ☐ Painting and murals ☐ Murals and sculpture
☐ I don't know the answer

2. What is the most famous Leopoldo Flores' work?

☐ "Sculptures" park and garden ☐ Leopoldo Flores Museum ☐ Cosmovitral
☐ I don't know the answer

3. Leopoldo Flores is considered the Master of:

☐ Movement, color and texture ☐ Movement, color and light ☐ Color, shapes, and murals
☐ I don't know the answer

4. Tell me what you know about the Minotaur's myth

_____
_____
_____

5. What was Ariadne's role in the Minotaur's myth?

_____
_____
_____
_____
_____

6. What was the name of Minos' wife?

☐ Eloise ☐ Clio ☐ Phasifae
☐ I don't know the answer

7. Who designed the Minotaur's labyrinth?

☐ Sophocles ☐ Daedalus ☐ Theseus
☐ I don't know the answer

8. From what island came all the people who were feed to the Minotaur?

☐ Sparta ☐ Athens ☐ Crete
☐ I don't know the answer

9. What animal was Phasifae in love with?

☐ Bull ☐ Dolphin ☐ Tiger
☐ I don't know the answer

10. ¿Who killed the Minotaur?

☐ Daedalus ☐ Minos ☐ Theseus
☐ I don't know the answer

University of North Texas
Investigación en "Museos y ambientes educativos virtuales en 3D"
(THpos02) General Knowledge

Name _____ Number _____
Please choose the right answer.

1. How many people were sacrificed to the Minotaur every year?
☐ Fourteen ☐ Twelve ☐ Twenty two
☐ I don't know the answer

2. What object Ariadne gave to the Minotaur's killer to get out of the labyrinth?
☐ A map ☐ A thread ☐ A compass
☐ I don't know the answer

3. Who killed the Minotaur?
☐ Daedalus ☐ Minos ☐ Theseus
☐ I don't know the answer

4. Who was Theseus' father?
☐ Cosmos ☐ Zeus ☐ Poseidon
☐ I don't know the answer

5. Who was Ariadne's youngest sister?
☐ Eloise ☐ Fedra ☐ Thalia
☐ I don't know the answer

6. What is the Minotaur's name?
☐ Aterion ☐ Estion ☐ Argos
☐ I don't know the answer

7. Who was Theseus true love?
☐ Fedra ☐ Ariadne ☐ Phasifae
☐ I don't know the answer

8. What color was the bull which Phasifae fell for?
☐ Black ☐ Golden ☐ White
☐ I don't know the answer

9. Who was Phasifae's husband?
☐ Daedalus ☐ Minos ☐ Theseus
☐ I don't know the answer

10. ¿Who designed the Minotaur's labyrinth?
☐ Minos ☐ Theseus ☐ Daedalus
☐ I don't know the answer

University of North Texas
Investigación en "Museos y ambientes educativos virtuales en 3D"
(THpos03) General Knowledge

Name _____ Number _____
Please choose the right answer.

1. What was the name of the island ruled by Minos?
☐ Thasos ☐ Crete ☐ Naxos
☐ I don't know the answer

2. After killing the Minotaur, in what island Theseus abandoned Ariadne?
☐ Thasos ☐ Crete ☐ Naxos
☐ I don't know the answer

3. Leopoldo Flores was born in this county:
☐ Ecatepec ☐ Tenancingo ☐ Tlalnepantla
☐ I don't know the answer

4. What year Leopoldo Flores was born?
☐ 1941 ☐ 1937 ☐ 1934
☐ I don't know the answer

5. In which island the Minotaur's labyrinth was located?
☐ Thasos ☐ Crete ☐ Naxos
☐ I don't know the answer

6. Who helped Theseus to escape the labyrinth?
☐ Phasifae ☐ Thalia ☐ Ariadne
☐ I don't know the answer

7. Who designed the costume Phasifae used to seduce the White bull?
☐ Daedalus ☐ Theseus ☐ Minos
☐ I don't know the answer

8. For what other name the Minotaur's labyrinth is known as?
☐ Ariadne's Labyrinth ☐ Theseu's Labyrinth ☐ Crete's Labyrinth
☐ I don't know the answer

9. Who was Ariadne's father?
☐ Minos ☐ Daedalus ☐ Poseidon
☐ I don't know the answer

10. Leopoldo Flores is considered the Master of
☐ Movement, color and texture ☐ Movement, space and light ☐ Color, shapes, and murals
☐ I don't know the answer

APPENDIX B

CONSENT FORM

Consent Form
Research in Virtual Museums
Autonomous University of the State of Mexico
University of North Texas

I certify that I have been invited to participate in the research in Virtual Museums that the University of North Texas is conducting, and that my participation is voluntary. I understand that the researchers are working to analyze perceptions and knowledge acquisition in museum visits, and how these are affected by having previous knowledge of the exhibition through a virtual museum tour. I've been informed that this study will last 4 consecutive days, in which I will be required to attend at least half an hour per day.

I've been informed by the researchers that I can withdraw from this study at any time, and that I won't be penalized or I won't lose any benefits that I might have received from this research. I acknowledge the fact that my participation can be stopped at any time by the researchers. I understand that there will be no risks involved in my participation in this study, other than those encountered in a day-to-day life.

I've been informed that my participation and interviews will be video recorded. This recording won't be published or distributed to outside sources, and won't be used for other purposes than the ones concerning the above mentioned research. I acknowledge that I have the right to skip any question I choose not to answer.

I acknowledge the fact that the results of this research might be published in scientific journals or conferences in the future, but my identity won't be published and my personal data will be kept confidential.

I authorize the use and publication of my video recording, and my answers to the interviews and questionnaires exclusively for the above mentioned research.

I am to contact the principal investigators Dr. Greg Jones or Adriana D' Alba in the Department of Learning Technologies at the University of North Texas at (940) 565-2571 if I have any questions about this study.

By signing, I agree to participate in the research after I've discussed the information presented in this consent form and I declare that I received a copy of this document. Also I confirm that I am at least 18 years old.

Name_____

Signature _____ Date _____

APPENDIX C

PILOT STUDY

Measuring the Effectiveness of a 3D Virtual Museum

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Adriana D'Alba
William Jones
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Abstract

This study reports results of a joint research project between the University of North Texas (UNT) and the Autonomous University of the State of Mexico (UAEM). The study examined the effectiveness, usability, and knowledge acquisition between the Leopoldo Flores Museum located at the UAEM and an online virtual environment replica. The primary results show a) students using the virtual environment first and then visiting the museum exhibited better knowledge acquisition about the museum and had higher level of discourses when on the guided tour, and b) the virtual museum experience, when used alone, was a comparable experience to the actual museum guided tour in both knowledge gained and satisfaction.

Museums provide society with cultural and historical collections of materials and information. Their educational role in society is well established and long standing (Hooper-

Greenhill, 1994). However, not everyone can visit these museum collections and as a result are missing that source of interaction and knowledge (Boffey, 2011). Visitation to museums around the world has been growing in recent years. Between 1998 and 2006 museum visits in the United States grew from 500 million to over 1 billion (Griffiths, King, & Aerni, 2007; Hein & Alexander, 1998). Museums in Mexico have experienced similar growth, reaching a total of 44 million visitors in 2004 (CNCAC, 2006). While these numbers are impressive, many museums still only support regional and local patrons and visitors.

In an attempt to expand museum access to visitors from a wider geographic area, some museums use their web sites to support online exhibits. These online exhibits vary greatly in look and feel. Most online museums allow visitors to contemplate selected pieces of the museum's collection in interactive, 2D image format (Smithsonian, 2002). A few, have been exploring the use of 3D virtual environments in proprietary, non-persistent virtual worlds designed and developed for select audiences, such as teachers and students (Urban, Marty, & Twidale, 2007). These 3D virtual museums are trying to exploit the potential to provide students with stimulating, immersive, and easy-to-use educational resources that are credible and do not require elaborate technical skills (Jones, Morales, & Knezek, 2004). Proponents suggest this technology will appeal to the next generation of teachers and students, whose technological skills and web experience allow for greater utilization of a virtual environments' functionality for innovative student-centered constructivist learning (Abram & Luther, 2004; Branston, 2006; Dede, 2005; Jones & Bronack, 2006). The advantage of these virtual and online museums are that they expand access to visitors without having to leave their homes or classrooms (McKenzie, 1997). This growth in online museum representations has seen an accompanying rise

in research conducted on the issue of their use, effectiveness, and viability. The following two studies discussed are of particular note due to their research focus related to the research project.

The first study conducted by Hendricks, Tangkuampien, and Malan (2003) examined virtual museums delivered via web and 3D virtual spaces. The research focused on examining participant's enjoyment, interest in the artwork, encouragement to explore the virtual space, effectiveness of the interface for learning, distraction within the environment, and time spent reading and interacting with the environment for each of the presentation methods. One of the primary results of the research showed an increased interest in the artwork, enjoyment, and encouragement to explore more when a participant used the 3D environment over the web-based interface. The second study conducted by Syaiou, Mania, Karoulis, and White (2009) published findings from a quantitative research project that explored the relationship between presence and enjoyment in a virtual museum space. Using the Augmented Representation of Cultural Objects system (ARCO) they developed the 3D museum space. The researchers used two instruments, the first was the Slater's Virtual Reality questionnaire that measured presence and the second was the Regenbrecht and Schubert's Augmented Reality questionnaire that measured the degree to which individuals experienced the presence of virtual objects in a real environment as the subjective impression they appear real. The results showed that building a virtual environment system to match the human perceptual and motor systems is essential. They found that the accurate representation of the space is required to induce spatial awareness and subjective feelings of enjoyment within the virtual space similar to the real world version.

The research presented in this study examines some of the research questions from the studies above and specifically explores the research question of educational effectiveness of a 3D

virtual representation to that of an actual museum. The research was not to trying to find a substitute for visitations to museums, but to offer people who cannot attend those places the possibility to access at anytime and anywhere the valuable information museums hold within their walls. The following research questions drove the mix-method research:

- How does a visitors' knowledge acquisition differ between an actual museum tour and the virtual space?
- In what ways would visitors' discourse be affected by previously experiencing a self-guided virtual tour of the same exhibition?
- Can a previous self-guided virtual tour affect visitors' experience in a museum tour?

The Research Project

Over a period of nine months between 2010 and 2011, the research team of Dr. Greg Jones, Adriana D'Alba, and William Jones from The University of North Texas (UNT), joined with the Autonomous University of the State of Mexico (UAEM), in the examination of the differences in knowledge acquisition and interaction between an actual museum and its virtual environment replica. The research was funded by a joint research grant between UNT and UAEM to promote interdisciplinary research. The UNT team visited the UAEM museums in May 2010 and working with Ms. Abraham Jalil, the UAEM project representative, selected the Leopoldo Flores Museum exhibit called "The Minotaur in the Labyrinth" to be the content used in the research project. The selected exhibit consists of ten large-scale paintings, some as large as fifteen feet by seven feet, depicting the Greek myth of the Minotaur. The paintings were created in 1983 and are displayed as a collection in its own three-story building. Visitors enter the top of

the exhibit and take a spiral ramp down to the lowest level, revealing different aspects of the collection as they descend. Figure 1 shows photos of the exhibit. This exhibit fit the research criteria of the project because a) the chances would be low that the potential participants asked to take part would have previous knowledge of the exhibit, b) the collection is a self-contained exhibit space thus minimizing extraneous distractions, and c) the size and style of the exhibit allows for a 3D rendering that requires a limited number of interactions to replicate the learning experience reducing the complexity and time of development of the research.

Once the exhibit was selected, Adriana D'Alba created the digital rendering of the museum using Autodesk 3DS Max software. Architectural plans, high quality photos, and movies taken on the visit in May of the space were used to ensure accuracy of the virtual museum. Figure 2 shows images of the final virtual environment before lighting was added.

Dr. Jones's 3D Online Learning Environments lab at UNT then integrated the digital rendering of the museum into the CRG framework, which has been supporting this type of 3D virtual environment research since 2003 (Jones, 2005; Jones & Christal, 2003; Jones & Kalinowski, 2007; Jones & Overall, 2004; Jones, Overall, & Knezek, 2003; Jones, Robertson, & Warren, 2009; Jones, Squires, & Hicks, 2008; Jones & Warren, 2008). Transcripts from actual guided tours, captured from the earlier visits to UAEM, were used to identify and create the learning content and interactions. The results were that a person touring the virtual museum could click on exhibit pieces to trigger narration and text about the item identified. The CRG framework enabled the development to be done within a rapid four-month period. A limitation to

the planned research began to emerge at this point in the development. The virtual environment was being designed to provide a single-user experience, but after discussions with the museum representatives at UAEM the interaction at the museum was only going to be available as small group tours. Martha Khun, a graduate research assistant from UAEM, visited UNT in the fall of 2010 and assisted with the usability testing of the software. The user tests resulted in several improvements that helped improve reliability and quality of interaction to more accurately reflect the real museum tour to be provided later in the research. The created virtual rendering of the museum passed user testing in November 2010. Data collection was then confirmed to occur in December 2010.

The Study

In December of 2010, Adriana D'Alba traveled to UAEM for six days to collect data regarding the research problem of measuring the effectiveness, usability, and knowledge acquisition of students visiting the 3D virtual museum and of students visiting the actual museum. Martha Khun, who had visited UNT earlier in the project, assisted Adriana during this stage of the research at UAem. Figure 3 shows some photos from the on-site research.

Participants

Information regarding the research project was distributed to undergraduate students studying at the College of Architecture and Design at UAEM. Eighteen undergraduates volunteered to participate. Each of these students stated that they had never been to the Leopoldo Flores Museum exhibit before. Sixteen of the eighteen students completed the study. Table 1

provides information on selected demographic details of the participants. One of the more interesting patterns seen in the demographic data had to do with regular access to the Internet and computers. Students in Mexico typically have less access to computers prior to college (comScore, 2011) and this is illustrated by the number of students just recently using computer software, (18.7% in the last three years) or never playing online games (62.5%) in this study.

Data Collection

Prior to the arrival and start of research, the UAEM representative had started the recruitment outreach as discussed above. The UNT research team spent six days at UAEM conducting the research. The day prior to the start of data collection was used to setup and test the virtual museum software in the assigned computer lab and to review the research project with the UAEM representatives and tour guides. Data collection then occurred in four stages over a five-day period. Day one saw a) participants take the pre-test on knowledge about the exhibit, b) were randomly divided into two groups, c) completed their first day museum activity, and d) completed the second knowledge test after their museum interaction. Day two saw the groups do the other form of interaction and complete the third and last knowledge test. Observational data was collected as well during days one and two of each groups interactive stages. Single and group interviews were conducted on days three through five.

Stage 1 – Pre-Test: Participants received a twelve question pre-test about the exhibit's artist and the Minotaur myth. The research team then randomly split the participants into two groups labeled MUS1 (9 students finished) and VE1 (7 students finished).

Stage 2 - First Interaction and Test: A tour guide from the museum led MUS1 through the actual museum first, presenting information about the exhibit and answering questions. In contrast, group VE1 took a self-directed tour of the online virtual museum first, utilizing the interactions embedded in the virtual environment to learn about the exhibit. Observational data in the form of videotaping and field notes were captured for each interaction. After completing their respective tours, the participants received a second twelve-question test that assessed knowledge gained about the artist and the exhibit.

Stage 3 – Second Interaction, Test, and Surveys: The groups then switched, with group MUS1 completing the virtual museum tour individually and group VE1 taking the museum tour with the guide. Observational data in the form of videotaping and field notes were captured for each interaction. After completing the second tour, participants received a post-test that further assessed knowledge acquired during the study. After last knowledge test, the participants were also asked to complete four surveys. The surveys measured virtual museum satisfaction (12 items, alpha .876), real museum satisfaction (12 items, alpha .864), usability (12 items, alpha .846), and technology (10 items, alpha .713) compared the virtual museum and the actual museum guided tour. The four instruments used came from previous research (D' Alba, Najmi, Gratch, & Bigenho, 2010; D'Alba, Gratch, & Jones, 2010). The surveys and scores from knowledge tests were then analyzed to help with the interviews that were to follow.

Stage 4 - Interviews: The students agreed to participate in semi-structured interviews at the end of the research along with one group interview. The interviews allowed the researchers to have participants discuss issues and themes that emerged from the data analysis in more personal terms. Interviews lasted between fifteen and thirty minutes. All the interviews were conducted in

Spanish, since all students spoke Spanish as their first language. the research team conducted semi-structured interviews using the initial collected results from the tests and survey to drive the initial questions (Creswell, 1994). While there is no way to guarantee full anonymity in descriptive research, all steps were taken to limit the possibility that traceable information might become known (Lincoln & Guba, 1985, p. 155). The research team showed rigor and trustworthiness by defining, establishing, and showing credibility, transferability, dependability, and confirmability both during and at the conclusion of the study (Lincoln and Guba 1985). It should be noted, that due to limited time available in Mexico for the interviews, there was a limit to the number of single interviews and group interviews that could be conducted. This lack of additional follow-up interviews impacts the prolonged engagement of the research and might have limited the depth of patterns and themes discovered during the research.

Results

Stage 1 Results – Pre-Test: Participants received a twelve question general knowledge pre-test about the exhibit's artist and the Minotaur myth. On the pre-test scores, group MUS1 answered 27.7% (mean) correctly while group VE1 scored 27.3% (mean) correctly, demonstrating a very similar level of knowledge about the artist and the Minotaur myth before the tours began.

Stage 2 Results - First Interaction and Test: The second knowledge test was given after each museum interaction with group MUS1 scoring 86.2% (mean) and VE1 scoring 85.7% (mean). Both groups gained about the same amount of knowledge based on the test given after group MUS1 had the guided tour and group VE1 had the single-user virtual environment

museum interaction. Upon examination and analysis of the observational data collected during the guided tour session of group MUS1, the students did have some additional interaction as expected with a 'live' tour guide being available that could not be controlled for. As noted above, the single-user virtual environment was limited to some extent by not being able to support this type of interaction to students in group VE1 during this first stage. It should be noted, participants using the virtual environment received very limited instructions on how to operate within the space. Participants completed the tour with few issues, confirming the usability and intuitive nature of the virtual museum, even among a population with very little gaming experience. This was the same when group MUS1 used the virtual environment.

Stage 3 Results – Second Interaction, Test, and Surveys: After the completing the second swapped tours, each group received a new set of knowledge questions about the exhibit. Group MUS1 scored 87.8% (mean) after using the virtual environment and group VE1 scored 91.6% (mean) after the guided tour of the museum. Upon examination and analysis of the observational data collected of the museum tour by group VE1, we noted an increase in the number of times questions were asked or of interactions with the tour guide and other students during the tour. Data coding shows that the VE1 group was more engaged during the museum tour after the virtual tour as compared to the MUS1 group who had the museum tour first. These differences will be explored in more details in the next section.

Stage 4 Results – Surveys and Interviews: The team transcribed and coded the interviews based on the method developed by Glaser and Strauss (1967). The research team selected the constant comparative method for analyzing interview data (Creswell, 1994) and then triangulated

the interview results with survey and knowledge tests. As a result, the team discovered groupings contained within the raw data.

The survey results indicate that a majority of the participants (~93%) rated the real museum as a "fun" experience, while slightly fewer participants (~75%) rated the virtual museum as "fun." When asked about which space was engaging, the participants rated both spaces as engaging (~75%). Interviews confirmed these results. The majority of the students (~93%) felt they learned a lot from the virtual museum interaction, while slightly fewer students (~87%) indicated having learned a lot from the guided museum tour experience. This is interesting, since the participants preferred the real museum to the virtual in the surveys, but reported that they learned more in the virtual environment. Participants felt that the virtual museum was better because they could focus more on the information being presented. Participants identified a lack of distractions as an important part of their virtual museum experience and credited this characteristic as the reason they got more from the interaction.

Participants who visited the real museum first spent a lot less time in the virtual environment. The median of time spent in the virtual museum for VE1 was eighteen minutes, while the median for MUS1 dropped to twelve minutes. When this result is compared with the observational data and the click data of the virtual environment collected on the server, VE1 participants that used the virtual environment first spent more time interacting (clicking), reading, and listening to all museum content as compared to MUS1 participants who visited the actual museum first. The MUS1 participants clicked on less than half the number of interactive items in the virtual environment and this alone would translate to fewer screens to read and listen to and result in less time spent doing the virtual interaction. The limited number of interviews did

impact this emergent theme, since additional interviews would have allowed us to more fully understand the reason for this observation. The observational data and movement data from the server from within the environment indicates that the MUS1 participants simply moved through the environment and clicked on fewer things.

During interviews, the participants indicated that the virtual museum provided more depth of information over the guided tour. Forty-three percent of the participants agreed with the statement, “My experience with the virtual museum encouraged me to seek more information about the artists/pieces in the tour,” compared to ~68% who felt they needed to seek more information after visiting the real museum. We were unable to determine from the data collected if any of the participants after their first interaction went online to learn more about the exhibit before the second interaction. This theme might indicate that more of the VE1 group because of the nature of the experience might have done additional learning before the second interaction as compared to the MUS1 group. Since we do not know, we cannot say for sure if this increased interest in seeking more information affected the knowledge tests conducted during the research.

Participants also indicated that they felt more satisfied with the information and learning experience in the virtual environment compared to the real museum. As mentioned above, one of the most interesting results was that group VE1 had considerably more interaction between the students and their guide as seen in the observational data during their real museum tour. During the group interview, the participants were asked about this issue and the responses indicate that the VE1 group was just better prepared for the real museum tour because of the virtual experience before hand. It is our belief that the participants were more prepared for the real

museum tour because of the creation of participant's cognitive scaffolding during the virtual museum interaction. Our next research study hopes to look at that question in greater detail.

Conclusion

The research found several important outcomes. The first was that the Museum group (MUS1) and Virtual group (VE1) had had approximately the same knowledge acquisition after the first interaction for this group of participants. The second was that VE1 participants that used virtual environment first and also visited the museum had higher content knowledge measured. The combination of both the prolonged virtual environment interactions and the higher discourse and interactions seen during the guided tour seem to be factors in improved knowledge acquisition. Upcoming research will focus more on this issue looking at cognitive scaffolding and use of pre-visualization as it relates to knowledge acquisition when the virtual environment is used. This outcome would be similar to other types of simulations such as America's Army virtual environment training section of its game, were the AA environment is used to inform soldiers about basic training before they start. This pre-visualization of the environment has been reported to increase outcomes. In conclusion, this research is another step in demonstrating the potential educational value that virtual environments can provide.

APPENDIX D

PERSON AS INSTRUMENT

During my undergraduate studies in Graphic Design (1989) at the Autonomous University of the State of Mexico (UAEM), I struggled to find a way to be more efficient when developing projects for my classes. Back then, software for computer graphics was expensive, and students in Mexico did not have easy access to it. During the last year of my studies, I was able to acquire a computer, and that tool opened new possibilities for me. Papers that took me days to type in an old typewriter now were done at a faster pace; graphics were created in a more efficient way using software such as Corel Draw© and PhotoPaint©.

When I graduated in 1994 my first job was producing graphic presentations using PowerPoint© and Corel Draw© for different clients. Then, I was hired to work in a company named DSInet that developed web sites and business software. Back then Macromedia Dreamweaver© had not been released, so I had to build web pages using HTML code. After several years working for DSInet and other companies that focused on graphic production and multimedia, in 2002 I was asked to teach undergraduate courses in multimedia at UAEM.

One of the first things I noticed is that students were being taught the same way I was taught back in 1989. They were about to graduate and did not have a strong knowledge on the latest graphic applications. Several professors did not have professional experience, and they were teaching their students using the same curriculum that was taught to them ten years ago. It was appalling.

During the three years I taught at UAEM and the Instituto Universitario del Estado de Mexico (IUEM), I tried to instruct and engage my students using practical

activities and lessons, so they could create and understand their own concepts. My philosophy was 'learning by doing', so I always challenged them with hands-on activities and tried to reflect with them the importance of acquiring new knowledge. I also taught them that they have the right to question things, but with that right there is a responsibility: they have to be capable to answer these questions.

Using multimedia technology in the classroom, I enhanced my students' learning experience. I am certain that teachers have an advantage that back in the 90s they lacked, which are technological applications for education. Now is common to use virtual environments, audio, podcasts, internet resources, online quests and scavenger hunts, videos, and forums, as exceptional technological tools to deliver content in the classroom. A teacher can show the movement of planets using a video. Another teacher can use a virtual environment to show the students how the Sistine Chapel is decorated without leaving the classroom. The possibilities to improve the educational experience using technology are infinite. However, I strongly believe that not only is it important to apply these new technologies in education, but also it is imperative to assess their results.

In 2004 while I was at the movies I remember watching a commercial that used three-dimensional (3D) graphic animation. I was fascinated. It was incredible to observe a little piece of popcorn dressed with a small cape and a hat, flying from the machine directly to the popcorn bucket, and then joining other little pieces of popcorn to dance in front of a camera. I knew instantly I wanted to learn how to create 3D animations.

I began to research where I could learn this technology, but unfortunately in my country those types of courses were not available at that time. I found that the Glasgow School of Art was offering an intensive Masters program in 2D/3D animation graphics. I applied for a scholarship through UAEM, and in the fall of 2005 I traveled to Scotland to begin my masters. Over the next two years I learned how to use the latest technology in audio and video to create two-dimensional and three-dimensional animations and 3D virtual environments. Living in Scotland also provided me with the opportunity to travel and visit other countries in Europe.

While I was studying in Europe I was very fortunate to visit some of the most beautiful museums. I believe the information and the pieces these places exhibit are unique, and the buildings that hold those pieces are without equal. I remember I was in the D'Orsay Museum in France attending a Van Gogh exhibition. I was deeply moved by it and I wished more and more people could see it and have that personal experience. That is when the idea of creating accurate virtual replicas of the museums came to my mind. I thought I could offer people the opportunity to have a similar aesthetic experience using tools such as three-dimensional environments and the internet, without sacrificing the very important educational aspect of the museum tours.

In 2007 when I was about to finish my masters degree, I was looking for an institution to study my PhD. I was not sure what I wanted to study but I did know what I wanted to do for research. I was looking for literature on research in virtual museums and I read a couple of articles that Dr. Greg Jones had presented at conferences. I looked for his resume and noticed that he was an Assistant Professor at the Learning

Technologies (LT) Department at the University of North Texas (UNT). I wrote him an e-mail requesting information about the PhD program. I applied, and I got accepted to start my PhD studies in the spring of 2008. Dr. Jones became my major advisor.

I was very fortunate to get a job as a research assistant at the LT advanced research lab the first semester of my coursework. This job allowed me to learn about the different research projects that were being developed at the department, and I was able to get involved in some of them.

One of my first research projects at the LT department back in 2008 was the project Chalk House (Jones & Warren, 2008). Although I was not involved on the research aspect of the project, I was in charge of the re-design of the 3D graphics of the environment. My knowledge in 2D/3D motion graphics and my expertise in 3D Studio Max allowed me to work on the graphic requirements of the project. I was also responsible for the re-design of the Institute for the Integration of Technology into Teaching and Learning (IITTL) web site.

In 2009 I was the leader of a research team that developed a product named oLTECx (Online Learning Technologies Experience). The primary goal of the oLTECx was to explore the use of a two-dimensional, narrative based, virtual learning environment (VLE) to orient potential students to their University departments' degree programs, faculty, and course offerings. After exploring the environment, participants were surveyed about their experiences. Findings and reports included the instructional design of the online environment, validation of the assessment instrument, and possible correlations relating to learning through games, engagement, and game design. This

research project generated multiple conference and journal papers not only by me, but by all the students involved.

In addition, in 2010 I was involved with Dr. Jones in a joint research funded by the Autonomous University of the State of Mexico and the University of North Texas named 'Seed Grant'. The first research phase of this product entitled “Research in museums and educational 3D virtual environments” explored the use of existing 3D virtual technologies to bring museums into online 3D experiences, assessed the usability of the online environment, and examined its pedagogical approaches. This research was also the core of my PhD dissertation.

While developing my literature review in virtual museums I realized that I did not have a lot of knowledge in museum education. In the fall of 2008 I contacted Dr. Rina Kundu at the UNT School of Art to see if I could take a couple of courses to become more familiar with the topic. Dr. Kundu suggested me taking a seminar in museum education that was going to be offered in the spring of 2009. After I finished the final course of the seminar in the fall of 2009, she encouraged me to pursue a certification in Museum education, which I concluded in the fall of 2011.

One of the requisites for the certification required me to perform a 300 hour internship at the Dallas Museum of Art (DMA). After several weeks working at the exhibition floor, attending staff meetings, and learning how to develop different educative programs offered by the museum, I started to get more involved in the evaluation process of these programs. At the end of my internship I successfully presented the evaluation of the Center of Creative Connections (C3) and the evaluation

of the Late Nights program. The main objective of the study at C3 was to discover the purposes for repeat visits, why certain types of visitors attend certain groupings of programs, and to discover the social groupings of C3 visitors, including the percentage of visitors who come as families. The objective of the study for Late Nights was to discover the demographics of the visitors, as well as their preferences and opinions for attending that specific program.

During the course of my PhD studies I developed a number of professional relationships which helped me to continue improving my philosophy of teaching, and assisted me in building up a stronger research agenda. As a research instrument, I am aware that not only these relationships, mentoring, research projects, and philosophies have shaped the course of the research presented in this dissertation. It has also been determined by my own unique cultural and social background, which included a set of experiences, values, preferences and attitudes. It is my hope that these factors and the results of this research will strength the argument in favor of using online virtual environments for learning.

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