The Educational Experience of Virtual Reality: An Archaeological Case Study of the Maya Site, Vista Alegre

Jessica M. Moss
THE EDUCATIONAL EXPERIENCE OF VIRTUAL REALITY: AN ARCHAEOLOGICAL CASE STUDY OF THE MAYA SITE, VISTA ALEGRE

by

JESSICA M. MOSS

Under the Direction of Jeffrey B. Glover, Ph.D.

ABSTRACT

Archaeological visualization has a long history within the discipline, relying on technological advancements to aid in recording, interpreting, and educating about sites and projects. Though computer graphics have been used as archaeological visualizations for decades, hardware advancements have begun to allow for broader consumer use of Virtual and Augmented Reality platforms in homes, schools, and museums. This thesis explores the applications of Virtual and Augmented Reality platforms for archaeological visualization, specifically in the area of public education. To this end, a 3D model and virtual experience of the Maya site of Vista Alegre in Mexico are created, methodologically explained, and examined to relate history, theory, and the goals of utilizing this medium within the archaeological discipline while expanding on the ethical requirements and empirical methods of praxis. In all, this technology both produces tangible, quantifiable, and accurate data and makes these data more accessible to the general public.

INDEX WORDS: Maya archaeology, Public archaeology, Praxis; Digital visualization; VR; AR; Museum exhibition; 3D modeling; Point-cloud; Virtual reconstruction
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DEDICATION

I don’t know if I will ever have a speech at the Oscars or a Nobel Prize ceremony, so I will use this chance to give my thanks to the most important people in my life, for supporting me, watching out for me, and allowing me to somehow exist comfortably in modern society.

First, my parents: you dealt with me through a lot of madness, and if it were not for the balancing forces of both of you in my life, I never would have had the patience, support, and drive to do any of this. Literally. Next, to my fiancé: you keep me grounded, and we make the perfect team. You are the best other half a girl could wish for, AND you understand my obsession with animals, especially our kittens. Tyson and Firefly, you have contributed many hours of purrs and sleep next to me while I work on this thesis. You did this as much as I did.

To Loren Bouchard and H. Jon Benjamin: I know it is silly, but I would have given up ages ago without the optimism that your creative efforts bring to the world (just ask my fiancé). And finally, to whomever happens to be reading this, thank you. What is the point of spending so much time, energy, and stress to write unread words? From experience, I know that the main audience for this thesis is my committee members and other students. My committee members, I have already thanked (though no amount will ever be enough), but to any future students, I dedicate this lastly to you. I am aware that this could feel hollow, since it is most likely we have never met, but I hope that something in here is helpful to you in your pursuits. Mine the references, visit the websites, follow the recommended tutorials, but whatever you find, I hope it is useful. If it weren’t for hundreds of moments of silent support from the other students, teachers, and staff of the anthropology department, I never would have finished this. For them and for you, I plan to keep spreading anthropology like Wonder Woman spreads justice, because the world that we live in needs the anthropological perspective. To quote a genius, “Excelsior!”
This project would not exist without the help of a great many people. Primarily, my advisor Jeffrey Glover provided endless support and much-needed direction. I would like to extend my gratitude for his patience and guidance through this entire process. Through him, I met the rest of the Proyecto Costa Escondida team and became introduced to the wonders of the Maya world, two things that I am very thankful for. Dominique Rissolo, another PCE teammate and member of my committee, also facilitated my introduction to the Maya and many of the technological methodologies used by the industry. Nicola Sharratt graciously joined my committee at a late stage to guide the application of my project to the history of visualization and for an iteration destined for a museum. The final member of my committee, none of which I could have done without, is Kathryn Kozaitis, who introduced me to the world of praxis. In this, I found the way to apply my passion for archaeology to my goals of educating the public outside of academia. I am so grateful for everyone on my committee for devoting the time to guide me to find the knowledge that I seek to gain the foundation to ethically educate others.

In addition to my committee, I would like to acknowledge that this work is built off of the countless hours of research from other archaeologists, especially though providing the background data associated with this project. These other members of the PCE exposed me to the many niches of archaeology as they apply practically to individual projects, and through them and their work, I have been able to see the interconnections and wider scope archaeological research. I am also very grateful for the residents and local stakeholders that allow us to work in these locations, often on personal land, and entrust us with investigating and handling their cultural heritage. Thank you for that trust, and I hope our work honors your heritage.
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1 INTRODUCTION

In May 2015, Islamic State (IS) militants seized the UNESCO World Heritage archaeological site of Palmyra in Syria. The site represented material from a long history of occupation spanning from the Neolithic in 7500 BCE through Assyrian, Roman, Persian, and Ottoman rule as a populous trade hub between the Silk Road and the Mediterranean (UNESCO 2018). Owing to this varied and complex political history, Palmyra’s monumental architecture drew inspiration from a variety of periods, traditions, and institutions providing unique insight into the effects of social change upon the population and practices of this area over time. It was also due to this extremely diverse history that Palmyra became targeted by the fundamentalist IS militants who saw the site and the history that it represents as anathema to their religious beliefs (Figure 1-1). While propaganda videos featuring the destruction of the temples, larger statues, and other architectural elements flooded the internet, leaders within the Islamic State aimed to seize anything that could be sold to fund their cause, extracting countless artifacts to be leveraged on the black market. Palmyra native Khaled al-Assad had spent his forty-year career as an archaeologist documenting the history of Palmyra, spending most of his professional life as the site’s director of antiquities before retiring to care for Palmyra in partnership with UNESCO (BBC World News). When IS invaded, they captured Assad, torturing him for over a month in an attempt to extract information about potential valuables within the site. Assad never relented, protecting what remained of his life’s work until he was publicly executed on the stage of Palmyra’s ancient amphitheater by his captors (BBC World News).

Willful human destruction of ancient sites has happened through time for a variety of reasons; in many ways, it is the only way that society can progress forward. Urban development and expansion erases sites regularly, and organization like UNESCO World Heritage attempt to
label and protect the most significant and ancient sites currently remaining. However, natural disasters, climatological change, or physical degradation from time will eventually damage all archaeological sites. The ephemeral nature of archaeological material requires constant vigilance in advancing the tools used for data capture and storage. In the case of sites such as Palmyra, the destruction of the site occurred publicly, quickly, and the previously collected data becomes all that remains. By focusing on using visualization tools to capture the built environment of a site, and using technological platforms developed for media industries, these data are able to provide a digital representation and record of a site in a way that is not subject to natural degradation. As the ubiquity of this practice increases, photorealistic models of sites are being incorporated into archaeological data collection workflows. The goal of this thesis is to explore how these models are created to maintain historical accuracy and the intersections of using these models for preservation, interpretation, and education.

The IS occupation of Palmyra lasted until March 2017, and whatever was not looted by the militants was either destroyed in battle or for religious and political propaganda. The rich deposits of history woven into the landscape have purposefully been all but erased within two years of a contentious war. Seeing this impact so directly etched on the archaeological terrain during the early phases of my graduate school education highlighted the unstable nature of human history, reflecting in Palmyra the countless number of potential wells of archaeological knowledge that have been extinguished during the approximately 10,000 years of human settlement. Art, writing, and oral tradition maintain impressions of the past, and technology often develops in tandem with the needs of human expression. Photographs, video, digital scans, and computer reconstructions are a few of the modern technologies available for documentation
of the physical environment, and they are rapidly being incorporated into many archaeologists’ tool-boxes for preservation, remote analysis, and educational presentation.

Figure 1-1: Palmyra before and after IS
(Photo from Worley 2016)

Though the physical Palmyra is mostly lost, use of these modern technologies has allowed for the virtual reconstruction of the site to begin, recreating many of the empirical aspects of experiencing the site as it was before the IS occupation. The #NEWPALMYRA (http://www.newpalmyra.org/) project runs on crowd-sourced creative commons visual imagery to digitally recreate many of the important architectural elements that defined Palmyra within the archaeological record (Figure 1-2). Bridging the realms of software design, activism, and archaeology, the project’s software and the visual data are open-sourced, democratizing the access and ability to contribute to the project (#NEWPALMYRA 2018). The community engagement and international awareness of the socio-political situation of Palmyra weaves together the past’s influence on the present in a tangible way, and projects such as
#NEWPALMYRA represent an ideal of praxis-based archaeology through actively directing social change towards education in the aftermath of devastation. The use of modern digital technologies can enhance preservation, public education, and archaeological education in a way that is available to everyone with access to a computer. Through exposing the public to areas, times, and people outside of their daily reach, we can encourage a more well-informed and compassionate public. This is the goal that inspired this thesis, and through the work of digital reconstruction and virtual preservation, I aim to continue expanding the educational benefits of immersive visual media within an archaeological context with my work at the Maya site of Vista Alegre.

1.1 Project Statement

Modern visualization technologies are allowing archaeologists new ways to document, research, and inform the public. Exploring how digital archaeological site data can be gathered and utilized to create immersive educational experiences is one of the goals of this thesis through practical application. The other primary goal is to consider the praxis-based utilization of this archaeological knowledge to educate the public in engaging and novel ways through
investigating the connections between immersive digital experiences and lasting educational practices as they apply to the archaeological discipline.

Utilizing the latest interactive visualization technology, this project expands on the ideas of virtual tourism and digital archaeology to make educational, accurate, and immersive experiences within Virtual Reality (VR) and, in future iterations of this project, Augmented Reality (AR) platforms\(^1\). Though this thesis will explore the broader theoretical implications of this technology, the practical aspect of this project will focus on the applications of these innovations in an archaeological context. At the Maya site of Vista Alegre, and in conjunction with the Proyecto Costa Escondida (PCE), I first reproduce the current environment within a virtual framework, one that can be visited online and within a Virtual Reality headset. The next stage involves creating accurate renderings of what this site would have looked like using current archaeological data, which supports an approximation of the site’s appearance during the Terminal Classic / Postclassic periods (A.D. 850 – 1100/1200). The final product of this project, a fully immersive view of Vista Alegre in VR, will be referred to as VA/VR.

1.2 Summary of Thesis

This thesis takes a dual approach to understanding the topic of reconstruction techniques and digital applications of these for didactic use by scholars and the public, the layout of the paper reflects this division. Chapters 2 examines the history, introduction, and current usage of reconstructive and immersive visualization in archaeology, particularly how it relates to the field of Maya archaeology. The second portion of Chapter 2 is devoted to analyzing several case

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\(^1\) VR is a totally immersive experience where a headset is worn that blocks off hearing and vision. Controllers track hand gestures and allow for movement and interaction with objects. Movement within a 5' by 7' space is supported, so you are able to move around objects. AR is supported through a wearable or handheld device, such as glasses, smartphone, or tablet that uses a camera and internal software to place an overlay onto the actual viewed world. Currently, VR and AR are in the early stages of developing consumer products, but the market for them is exponentially rising as the technology and its affordability improves.
studies with similar goals to that of the digitalization of Vista Alegre, including an academic project geographically nearby, a team working to digitally preserve cultural heritage with UNESCO, and an archaeologist working with PBS to educate the public using point-cloud visualization and VR. Though these case studies share many educational goals, the methods utilized in this project are different owing to the nature of the site. The case studies provide a nuanced understanding of the variety of solutions available for site digitalization based on the needs, goals, and nature of the site.

Chapter 3 turns more directly to theory, analyzing archaeological praxis and associated archaeological and anthropological theoretical frameworks. The main themes discussed are technology, accessibility, immersive and experiential learning, museum and other forms of display, and the application of praxis within the PCE. Following the theoretical foundation of the project, Chapters 4 examines the history of Vista Alegre, including the research undertaken at the site to date and the goals and methods of each PCE expedition. Chapter 4 also examines the current interpreted site chronology for Vista Alegre, with special attention to what will be represented in the 3D visualization for this project. The last portion of Chapter 4 is spent examining the particulars of the individual structures to be modeled at Vista Alegre, providing much of the background information for the stylistic details used in modeling.

Chapter 5 turns to the methodological steps utilized to create the model of Vista Alegre used for this project, beginning with the site background and description of the primary structures and features. There are many methods available to create similar visualizations, just as there are many different methods for data collection, and these are also discussed within the chapter(s), as well as my reasoning for selecting the methods and platforms used. Additionally, as technology is a rapidly moving target to aim for in any multi-year project, tools exist at the
time of this writing that were not available at the start of this endeavor. Footnotes have been added where appropriate to both describe elements of the technology as well as provide insight into the developments in both hardware and software. As this section delves into technology that may be outside of the knowledge-base of those less familiar with computing applications, a glossary is provided in Appendix A. Appendix B also lists the external learning resources and material sources that I used for this project, including the tutorials that I accessed for modeling in Blender. One of the greatest challenges of crafting this thesis has been embracing the ephemerality of technical knowledge; it often seems as though once a technique is mastered, it is rendered obsolete. Throughout this project, and described in detail in these subsections, I have endeavored to highlight the most sustainable forms of this burgeoning technology when possible.

With the methodology for the model explained, Chapter 6 places the construction of this model within the discussed theoretical framework, looking towards the future potential of synthetic reality use within the discipline. Chapter 7 reviews the relationship of this particular project with the theories and enactment of praxis discussed in Chapters 2 and 3 and explores necessary elements of praxis in its future application. As the scope of future integration of this technology is unknown, there is much speculation and development opportunity to set precedent of educational practice that center around praxis. As the first section of this introduction shows, community action and directed change can be achieved through education, democratization of data, and empathy, even following the most atrocious human actions. This thesis’ conclusion summarizes this approach alongside the findings of this project and future plans of its application.
2 ARCHAEOLOGICAL VISUALIZATION AND VIRTUAL REALITY

Visualization is a powerful tool in both the interpretation and presentation of archaeological data, and forms of visualizing archaeological material have been fundamental to the data collection, analysis, and presentation techniques from the beginning of the discipline. The unique attributes and spatial relationships of archaeological materials are exceedingly important to the science of archaeology, as these relationships provide the context for archaeological interpretation. In most situations, recording this information is much easier, more reliable, and accurate through combining quantitative and qualitative description with imagery. Reconstructions of site layouts and monumental architecture offer insights into questions of spatial usage, sight-lines, and ideological embodiment. Reconstructions also allow for the public to personally visualize sites in a relatable way. Museum exhibits use dioramas, maps, or reconstructive illustrations to provide experiential context to archaeological collections. Extending the idea of archaeological reconstructions into the realm of new visualization technologies, particularly VR and AR, provides a new way to interface with archaeological materials, leading to new interpretive and presentational possibilities. This chapter first focuses on the history and necessity of archaeological visualization, culminating in the theories and methods utilized in specific case studies relevant to the goals of this project.

2.1 A Brief History of Archaeological Visualization

In the eighteenth and nineteenth century, when archaeology was the pursuit of wealthy gentlemen scholars who also sought the thrills and colonial-era accolades of exploring exotic locales and collecting rare artifacts, sketches were commonly collected of the monumental architecture, statues, and writings of these rediscovered worlds. Mostly, these early drawings were used for the documentation of the artistic and structural wonders of sites, but a few early
practitioners like Thomas Jefferson also began to use sketches to record their excavation methodology. In the 1770s, Jefferson sketched the cross-section of a mound in what is believed to be the first formal, systematic excavation in the United States (Trigger 2006:117). Napoleon Bonaparte, during his attempted conquest of Egypt during the final years of the eighteenth century, brought a large company of French scholars along to document and study the ancient monuments; some of their work included speculative recreations of the sites during their use (Figure 2-1). These scholars formed an academy of researchers that worked alongside native inhabitants of Egypt, and this tenuous collaboration resulted in several volumes for the consumption by European elites of the highly illustrated Description de l’Égypte between the years 1808 and 1828, fueling the European trend of exoticizing Orientalism (Al-Jabarti 2004[1798]:171-178).
The classification of artifacts became the common dating mechanism for archaeological sites during the Culture-History phase of the nineteenth and early twentieth centuries. The idea that similar styles came into and out of fashion in specific areas at specific times allowed for details of pottery, iconography, and tools to be classified and ordered (Trigger 2006:224-230). This created a need for details to be recorded visually to create these classification systems (Figure 2-2). As these details became the scientific basis for typological classification, these drawings had to be as accurate and representative as possible, creating a shift away from the fallacies seen in earlier interpretive work and placing more importance on meticulous reproduction.

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Figure 2-2: Artifact detail drawings for chronological assessment
(Image from Oxford Handbooks Online 2018)

As the values and practices of modern archaeology solidified within the university system during the early to middle decades of the twentieth century, systematic site mapping and sketching the excavation process in addition to the iconography became a common practice, especially as technological developments in mapping and chronology techniques continued to refine the investigation process (Trigger 2006:290-303). Some artists moved past the
documentation to attempt to provide a recreation of what the sites may have looked like during their use. An early example, Austen Layard, who worked at the Mesopotamian sites of Nimrud and Kuyunjik in modern Iraq, created architectural reconstructions of palace interiors (Figure 2-3) from the vast quantity of Neo-Assyrian sculptures and texts excavated during the mid-1800s (Trigger 2006:70-71).

One of the most renowned early reconstructive artists in the New World, Tatiana Proskouriakoff, entered the field of archaeology from an architectural background, lending a new understanding to the engineering techniques used by the Maya (Solomon 2002:36). After working in Piedras Negras, Copán, and Chichen Itza, Proskouriakoff published a book of artistic reconstructions, *An Album of Maya Architecture* (1970[1946]). This remarkable book features twenty-nine monuments and cityscapes that were reconstructed based on Proskouriakoff’s knowledge of both the Maya and construction techniques, in addition to showing the reconstruction next to a drawing of the current state of the monument or building (Figure 2-4). Using solid lines to depict elements in-situ and dotted lines showing potentially associated material found in relation to the monuments, Proskouriakoff not only provides an image of the reconstructed world but also shows the reader what assumptions may have been taken in her analysis. To give further context, she includes a few paragraphs for each drawing, thoughtfully describing the process of systematically analyzing each monument.
Figure 2-3: Reconstruction of Assyrian Palace by Layard, c. 1849  
(Image from Royal Collection Trust 2018)

Figure 2-4: Line-sketch of Existing Hieroglyphic Staircase  
c. 1939, Copán, Honduras and (Right) Reconstructive Drawing. Note the attention to in-situ and interpretive demarcation  
(Image from Proskouriakoff 1970[1946]:36-37)
Though it does have its strengths over worded description, visualization is still mediated. Sketches, especially those depicting iconography, have often been recorded with unconscious bias towards imposing familiar symbols into foreign design. The contextualization offered by Proskouriakoff in her reconstruction is one way to mitigate against issues of misinterpretation and inaccuracy, but unconscious association is still a potential problem in interpretation. One classic example of this comes from the fieldwork of Jean Frederic Waldeck, who recorded the Mayan hieroglyphs of Palenque during the 1830s. Waldeck, biased by personal beliefs of a connection between the Phoenicians and the Maya, included drawings of non-native elephants into his documentation (Figure 2-5) (Coe 2012:1442-1452). Photography obviously added more uniformity to archaeological documentation, but even as cameras became more ubiquitous during the early twentieth century, they were still too difficult to maneuver in remote locations or on rough terrain for widespread use. The difficulty of lighting, the grain size in film, and the
general expense of the early cameras needed to catch the requisite details could not make up for the benefits of film, such as its relative storage longevity once processed. Despite the early difficulties of film camera use in the field, some archaeologists managed to capture some remarkable images of remote Maya sites, such as the work of Alfred Maudslay and his wife Anne during the late 1800s and early 1900s (Figure 2-6) (Sharer 1983).

Camera technology continued to improve during the twentieth century, each decade bringing smaller, more portable cameras and better solutions to keeping unprocessed film from light. With the 21st century came the digital camera, eliminating the necessity of film, with greater internal storage and higher resolution capabilities expanding each year. Digital
photography has solved many of the issues inherent with the earlier limitations of film, such as its expense, finite image capacity, and transport issues owing to its requirement of staying cool and dark. Further advancements in digital photography have created the many opportunities, such as the capacity to capture more detail than then human eye can see, waterproof camera housing for underwater photography, almost unlimited storage, video recording options within the same camera body, and the ability to create 3D images through photogrammetry software. Owing to the longevity, superior resolution, and tangibility of film, it is still the preference of some artists and researchers, though usually in combination with digital photographic data.

Even with modern photographic and mapping technology, there is the often-unconscious decisions of framing the image that can create assumptions of what is included, excluded, or related when interpreting the site. This can be especially problematic when attempting to present archaeological information to the public, as the public often lacks the expertise to interpret raw data. Museums, a primary public educator on archaeological material, often strive to use visualizations that are informative, unambiguous, and engaging, but this becomes difficult to do authentically when the data is inherently incomplete (Stone 1997). Larger-scale representations, such as models and dioramas, can help mitigate this interpretive gap, though they too have issues of accuracy in their interpretation and representation.
Models and dioramas make it easy for people to imagine that they are within a space, as these offer a more sensory experience than two-dimensional reconstructions. One beautiful example is found in the center of the Copán Sculpture Museum, located near the archaeological site of Copán in Honduras: a full-scale replica of the Rosalila structure (Figure 2-7). Oddly for the Maya, this early building phase, dating to the late sixth century AD, was preserved carefully before it was covered by subsequent construction, leading to Rosalila’s excellent state of preservation when uncovered under the current pyramid in 1989 (Asociacion Copán 2017).

Archaeologist Barbara Fash worked with local masons and artists to recreate an exact replica of what the archaeological teams found when they peeled back the layers of plaster and paint protecting the buried building (Fash and Fash 1996). Fash noted the multiple paint layers that were used during Rosalila’s period of use, and the team chose to represent the color scheme that adorned the building directly prior to its ceremonial burial to use on the replica (Fash and Fash 1996). This same polychrome scheme is used most often in reconstructions of Maya buildings, as Rosalila is the best-preserved example yet uncovered for this era and place.
However, not all reconstructions are as effective as Rosalila. One of the strengths of Rosalila’s reconstruction was that it was also an act of preservation; the original Rosalila was reburied and a full-sized replica was created, also acting as a form of experimental archaeology. The same cannot be said about the reconstruction efforts of Sir Arthur Evans working with the remains of the Minoan civilization in Knossos, originally dating to c.1600-1300 BCE. Coming from a very different ethical background than modern archaeologists, Evans excavated and ‘reconstructed’ many of the buildings around what he determined to be a palace during the early years of the twentieth century (Figure 2-8). Allan Klynne (1998) points to noted similarities between the reconstructions of Evans’ palaces with the Art Deco style of architecture that was popular at the time, though he also points to the argument that the Art Deco style was itself inspired by other archaeological finds around Knossos, thus creating a feedback loop making accuracy nearly impossible to assess (Klynne 1998:208). There is much that is difficult to verify in Evans’ reconstruction, as he greatly altered the archaeological evidence in his recreation of the site. Even famous elements of the site, such as the Tripartite Shrine, the colorful murals, and the
Palace of Knossos itself have been questioned by current site researchers for their legitimacy during more modern archaeological investigations (Klynne 1998:215-220). Additionally, the fame of the site and its visual reproduction on posters, postcards, and other tourism outlets has reified many of the inaccuracies and potential fallacies of Evans’ work within the public’s mind (Klynne 1998:207-213).

Modern ethical responsibilities recognize archaeology as a destructive science, and one that needs to mitigate this destruction through preservation and contextualization which is aided by technological developments. Klynne (1998:222-225) suggests that to make reconstructions viable sources of public education and interpretive data, they need to be part of the scientific dialogue, able to change and evolve visually through collaborative conversation and continued research. Critics were quick to point out that, while specifying some primary theoretical issues underpinning all of archaeological interpretation, the methodology for a self-reflexive reconstruction was vaguely developed within Klynne’s article (Hitchcock 1999; Molyneaux 1999). Technology had not yet caught up to the idea for a version controlled, collaborative reconstruction at the time of Klynne’s article in 1998, but now with the power of VR, AR, and open-source version control platforms such as GitHub, we may be on a path to crafting Klynne’s ideal reconstruction.

2.2 Interactive and Immersive Visualization - The Next Step

Constructing accurate digital models of archaeological sites using computer graphics has been a goal of many archaeologists since the genesis of computing. One early example in 1984 focused on creating an educational game called Mound Dig aimed at 11 to 14-year-olds to educate them about Viking history and archaeological methodology (Dean and Nichol 1984). Though the game lacked sophisticated graphics, this early educational interface worked on an
interactive turn-base system, similar to the classic Oregon Trail. Computer graphics swiftly improved through the 1980s, propelled by the early video game systems, such as Atari, and increased demand for CAD (computer aided drafting) software for the architecture and design industries. Though the creation of digital terrain modeling has its roots in the late 1970s, it was not until the mid-1980s that the computing technology allowed for more detailed 3D reconstructions of sites based on these data (Eisler et al. 1988:109-111; Reilly 1991). Early creation and use of these models required a great deal of specialized knowledge in low-level computer programming and database management, though Eisler et al. (1988) point to the benefits of this emerging form of visualization through their work in Egypt, in part to create a series of reconstructions showing the Mortuary Temple of Raneferef through various stages of construction (Figure 2-9). The list of benefits for this form of visualization includes “the flexibility and modifiability of the model and its individual parts”, “the capability of constructing very extensive models at a considerable degree of detail”, “the capability of making use of different graphic outputs based on a single set of data and a single model”, and “the suitability of the model as a base of a topological component of a database of archaeological excavation information”, among others (Eisler et al. 1988:121).

Figure 2-9: Digital reconstruction of the Mortuary Temple of Raneferef, 1988
From final construction phase (Image from Eisler et al. 1988:125)
Paul Reilly refers to these digital model reconstructions as ‘solid modelling’ and points to their use in animated tours and museum exhibits as early as 1985 “enable[ing] people to fully appreciate the scale and relationship of elements within a limited number of archaeological remains” (Reilly 1991:2). “Impressive though such enormous projects are,” Reilly (1991:2) cautions, “a gap still remains between the interpretation and the original data. It is not readily apparent how one gets from the dig to the interpretation”. As with the work of Proskouriakoff, Reilly emphasizes the importance of in-situ and interpretive demarcation.

Third party game engines like Unity or Unreal have been used in forms of archaeological display since they became commercially available in the 1990s; prior to this, most high-quality computer graphics rendering was either proprietary to a game console or prohibitively expensive (Kantner 2000). As the medium began to require less specialized knowledge and expense, digital modeling and visualization became more accessible to archaeologists as tools for both presentation and enhanced inquiry. Through the intersections of GIS, advanced computer processing and graphics, questions began to be asked regarding space that were previously unable to be addressed quantifiably, such as those examined in Michael Anderson’s (2004) work using digital model-based visibility analysis (along with the Unreal game engine) to understand use and privacy within a Pompeii residence (Figure 2-10). Though the use of the media became more common, the issues of accuracy and interpretation remained at the forefront of academic discussions regarding digital visualization. In John Kantner’s work of reconstructing the kivas of Chaco Canyon, he and his team of advanced students focused intently on the compromises and inferences made by the modeler, as much of the relevant data is always lacking to produce complete accuracy (Kantner 2000).
During the last decade, advancements in laser scanning, both airborne and terrestrial, have allowed for the digital reconstruction of highly accurate models of features, artifacts, and landscapes through point-cloud generation. Many modern techniques for digital modeling of archaeological sites rely on generating point-clouds through laser scanning or photogrammetric software, though the earlier methods of building digital models on geographical information systems (GIS) data still remains a common practice (as seen in this very project). Point-clouds are collections of individual points within three-dimensional space that record visual and locational data. Dense point-clouds can be indistinguishable from photos until manipulated in 3D space. Point-clouds, along with advancements in computer imaging software, game design, GIS, and remote sensing, have opened new techniques for archaeological investigation and
presentation in the form of accurate immersive environments with details recorded earnestly and accurately at the time of the data collection.

Constructing and navigating space is an experiential process, most accurately represented through full sensory immersion. Though technology has not yet brought us a form of full sensory immersion, it allows VR and AR users to engage more organically with the items and places. However, this technology is often used as an entertaining experience for the public, and is created in consultation with historians and archaeologists, though not under their direct control. Museums have contracted with technological visualization studios to create many experiences that seem more akin to amusement park rides than the VR and AR systems that are available on the commercial market (Figure 2-11). However, we are experiencing a rise in the commercial availability of VR and AR platforms, broadening opportunities for both use and program development by making it easier to access and learn these technologies. Some archeologists have extended their research into virtual reconstructions, both for public education and as interpretive frameworks, as will be explored further in the following case studies.

![Figure 2-11: Educational VR examples](https://i.ytimg.com/vi/M1er49GWjA8/maxresdefault.jpg) (Left) StonehengeVR by Voyager VR, currently featured at the Pacific Coast Science Center in Seattle, WA. From https://i.ytimg.com/vi/M1er49GWjA8/maxresdefault.jpg. (Right) Pulseworks VR Transporter at the Georgia Aquarium. (Image by author)
2.3 Case Studies

During the course of this study, the usage of VR and AR has continued to expand in both the academic and commercial markets. When I first approach this project in early 2016, Oculus Rift had just started shipping a consumer model and only a few dozen experiences were available. Pokemon Go had just introduced the smartphone-wielding public to the power of AR visualization by turning major cities into a global scavenger hunt for adorable animal sightings. The rapid adoption of these visualizations over the past two years speaks to their accessibility, and though this increase of usage for the mass market has only recently begun, the technology behind capturing and rendering 3D visualizations has been used in the industrial and academic settings for two decades, as discussed in Section 2.2. For this project, many examples paved the way for the techniques and methods used in data capture, interpretation, and presentation and are mentioned where applicable throughout this thesis.

The following three areas are featured below representing aspects of VR and archaeological integrations, and the specific case studies singled out from this larger body of work for particular study are owing to some key similarities to VA/VR. MayaArch3D, though not initially developed as a VR platform, weaves together photosphere tours, 3D renderings of the major site features, and acts as a detailed database for the project’s interpretive branch. Developed by archaeologists and art historians, MayaArch3D provides a great example of a digital visualization focused on an important Maya center.

While many institutions and industries use laser scanning, the work of nonprofit CyArk for UNESCO world heritage is inspiring and well-presented in a public interface. CyArk’s projects span the globe, and their primary focus is on accurate digital documentation of existing structures. These point-cloud-based 3D models act as both a repository of photorealistic digital
versions of our international cultural heritage and can be analyzed to reveal changes in these structures, from ecological or tourist factors, to aid in the mitigation of any preventable degradation. Their efficient methods and accurate results placed this UNESCO-partnered project within the case studies for VA/VR, though their methodology is very different than the methods selected for this project.

Though there are many examples of digital models and advanced 3D visualization used for public education in documentary television, PBS’ Ancient Invisible Cities not only uses the medium extremely well, but it is also hosted by an archaeologist. *Ancient Invisible Cities* is a short documentary series containing three episodes featuring 3D scanning visualization as a primary narrative technique to interpret and show the historical events of three cities, Athens, Cairo, and Istanbul. A companion website provides the scans highlighted in the series as VR environments that the public can explore. This admirable piece of public archaeology, hosted by archaeologist Darius Arya, provides a compelling example of deploying these visualizations in a multiplicity of media. As television is more accessible than VR hardware, this series emphasizes the value of public education and accessibility within this project.

![Figure 2-12: In-progress reconstruction of Temple 18 at Copán, Honduras](image)
though the object is still removed from context in web-based 3D viewer (Image from MayaArch 3D 2018)

![Virtual Tour of Copán in a web-based interface](image)

Figure 2-13: Virtual Tour of Copán in a web-based interface provides limited interactivity and immersion, but it still represents a powerful democratizing tool (Image from MayaArch3D 2018)

2.3.1 Academic Projects

There are some examples of current projects using digital modeling for both interpretive and educational purposes, and many of these are for projects in the Maya area. For example, Heather Richards-Rissetto and the work of the MayaArch3D team in Copán, Honduras, have used a combination of 3D modeling of buildings and features (Figure 2-12) and virtual tourism (Figure 2-13), which functions a lot like Google Street View (von Schwerin et al. 2013). Though not fully immersive, this form of visualization allows for visitors to the project website to explore the site by moving between photospheres creating an active engagement with the site. Photospheres recreate the 360º field of view and are placed at various points, usually several meters from each other to provide a remote guided tourist experience through the main avenues of the site. Unlike videos or photographs, individuals can spend time exploring details within each photosphere.
In addition to the photosphere-based visualization of the existent site, MayaArch3D’s project website also hosts a visual database of 3D models of important structures and sculptural elements. This approach combining the individual models with the modern condition of the site provides a foundation for the VA/VR project. Utilizing this website and visual database format adds accessible related information to the fully immersive virtual environment. In the case of MayaArch3D, the project began with individual structure modeling and web interface, planning to later expand to a fully immersive VR platform utilizing this data (von Schwerin et al. 2013). Owing to this, the structure and methodology utilized to reach their goals provides a uniquely applicable roadmap for the future development of VA/VR.

The MayaArch3D project also extends to ideas not yet encountered by VA/VR, but may be of particular use as the project expands. Owing to the size of the site, the MayaArch3D team constructed a way to use the size, height, and other quantifiable data for programmatic construction based off statistically created building typology (Table 2.1) and trigonometry to reconstruct the average size, height, and structural style (Table 2.2) from the archaeological footprint and construction material (Richards-Rissetto 2013). Once the typology has been determined, design templates based on well-researched reconstructions of the smaller site buildings can be placed within the model (Figure 2-14). In many ways, this is a more systematic and statistically meaningful answer to the 3D Atlanta issue of ‘dummy buildings’ (see below) as these are more than placeholders, and my goal is to use this form of typological modeling to fill in lesser known areas of Vista Alegre, where appropriate.

Though not directly applicable in Vista Alegre owing to its compactness, programmatic model generation can also speed up the reconstruction of dense urban centers, where most of the archaeological work has been spent on monumental architecture or the periphery is lacking in
site coverage (Richards-Rissetto 2015). The smaller buildings in Vista Alegre contain little remaining archaeological data and were most likely constructed from perishable material, such as the ‘Ancillary’ type and the Type 1 and 2 in Figure 2-14. It is also interesting to note the MayaArch3D team copes with issues of interpretation. Though these methods are very different than those applicable to Vista Alegre, this example demonstrates how to use this form of typology and associated visualization within 3D modeling.

Table 2.1: Harvard Site Typology for Copán reconstruction
(from Richards-Rissetto 2013:520)

<table>
<thead>
<tr>
<th>Site Type</th>
<th>No. of Mounds</th>
<th>Mound Height (max)</th>
<th>Construction Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3-5</td>
<td>0.25-1.25m</td>
<td>Small/medium-sized earth fill; undressed stones</td>
</tr>
<tr>
<td>2</td>
<td>6-8</td>
<td>2.5m-3m</td>
<td>Mostly undressed stones</td>
</tr>
<tr>
<td>3</td>
<td>6-8</td>
<td>4.75m</td>
<td>Mostly undressed stones</td>
</tr>
<tr>
<td>4</td>
<td>Multiple Plazas</td>
<td>10m</td>
<td>Large rough and dressed stones; often have vault stones</td>
</tr>
</tbody>
</table>

Table 2.2: Variables affecting structure heights
used with Harvard site typology for Copán Reconstruction (from Richards-Rissetto 2013:520).

<table>
<thead>
<tr>
<th>Site Type</th>
<th>Platform Height (m)</th>
<th>Wall Height (m)</th>
<th>Roof Pitch</th>
<th>Wall Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20</td>
<td>2.0</td>
<td>45°</td>
<td>N/A*</td>
</tr>
<tr>
<td>2</td>
<td>0.54</td>
<td>2.0</td>
<td>45°</td>
<td>N/A*</td>
</tr>
<tr>
<td>3</td>
<td>0.97</td>
<td>2.0</td>
<td>45°</td>
<td>N/A*</td>
</tr>
<tr>
<td>4</td>
<td>1.15</td>
<td>2.5</td>
<td>60°</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* Not applicable because thatch roofs do not require weight-bearing walls
To examine a project that is currently based in VR, Jeffrey Vadala (2009) examines the Maya site of T’isil in Quintana Roo, Mexico through modeling it in GIS and the Unreal game engine to use for spatial analysis. Moving around Vadala’s T’isil operates like navigating through a video game as the user can see the view-sheds and spatial separations created by the building and plaza placement (Vadala 2009). The methods used by Vadala to create a reconstruction based on survey data is very similar to those used within this project.

At his field-site in Sicily, Jeff Emanuel (2017) uses handheld AR tracking to show reconstructions of the Roman site of Morgantina (Figure 2-15). This type of visualization expands on the relationship between objects and space, situating them specifically where they would be in the modern place, thus making the experience both more immersive and tangible while at the physical site. However, when these types of experiences are made available through phone apps, Google plugins, or on websites, this approach to virtual tourism democratizes the experience of visiting these international sites while also mitigating the damage of large crowds.
to the site, adding additional benefits to supplementing on-site programs with remote accessibility.

Obviously, these case studies have the most relevance to creating a VR reconstruction of Vista Alegre, especially with regards to structuring the project for future use and technological development. As these represent goals that I aspire to with a future version of Vista Alegre, they provide an excellent roadmap for the current VA/VR project.

![Figure 2-15: Morgantina project showing hand-held tablet-based AR reconstruction of site (Image from Emanuel 2017)](image)

### 2.3.2 Laser Scanning, Industry and Nonprofit

According to the mission statement presented on their website, “CyArk is a nonprofit organization founded in 2003 to digitally record, archive and share the world's most significant cultural heritage and ensure that these places continue to inspire wonder and curiosity for decades to come” (CyArk 2018). Non-profit digital preservation companies, such as CyArk (Figure 2-16), work to document the present state of cultural heritage sites creating
photorealistic, volumetric point-clouds that can be explored for quantitative and qualitative data, in addition to creating manipulatable 3D objects for viewing (CyArk 2018). Laser scanning can also provide some interpretive functions as well. For example, the restoration of the Maya Hieroglyphic Stairway in Copán required the rearrangement of the hieroglyphic segments of the staircase that had fallen away (Figure 2-17). As the staircase told a narrative, it was important that the blocks be placed in their original order, but many of these blocks were quite fragile, and relocating them by hand multiple times would be time-consuming and potentially destructive to the archaeological record. Harvard’s Peabody Museum sent a team to scan the hieroglyphic blocks individually so that they could be digitally reconstructed (Figure 2-18), allowing for a more systematic and efficient reconstruction of the staircase (Tokovinine 2013).

Currently, laser scanners are very expensive, and they require specialized knowledge to use them. An alternative method of collecting data to create 3D point-clouds comes from advancements in digital photography and photogrammetric algorithms. Using a fixed-lens camera and taking a series of photographs with around 80% overlap can now create photorealistic 3D images (Figure 2-19), with excellent detail of features, excavation process, artifacts, whole sites, or landscapes (Prins et al. 2014). Both forms of 3D point-cloud generation require software, heavy computing power, and time, but as the technology improves, it is also becoming more common in the consumer market. During the last decade, 3D visualizations have entered the immersive virtual world of VR and AR frameworks with increasing frequency and accessibility, as seen by these case studies. The use of LiDAR is expanding into the heavily funded field of self-driving cars, so future units will be smaller and more cost efficient as the hardware manufactures rush to meet the demand of car-based systems (Cameron 2017.)

Understanding where these technologies are applicable for VA/VR can save time and resources
when expanding the project in the future. Though the site’s current state is unsuitable for
detailed laser scanning or photogrammetry for modeling purposes owing to the overgrown state
of the site, elements of these technologies are useful for artifacts or smaller feature visualization
within the larger project moving forward. For example, displaying these photorealistic
visualizations as discrete web-based elements (e.g., Figures 2-16 through 2-19), specific
educational material can be connected to these objects. Though not fully immersive, 3D
navigation of the objects facilitates curiosity and exploration, creating enjoyable web-based
educational experiences. CyArk excels at this format specifically for individual structures within
UNESCO heritage sites, creating a visual database that can be contextualized through maps,
associated structures, and research material. Combining this with photogrammetric
visualizations of the excavation process (review Figure 2-19) would provide a further contextual
element revealing some of the common methodology of archaeological practice to a web-based
audience.

Figure 2-16: 3D model of pyramid at Chichen Itza
created from terrestrial laser scanning (Image from CyARK 2018)
Figure 2-17: Digital 3D Scan of Ordered 16-steps of Hieroglyphic Stairway in Copán by Peabody Museum for digital reassembly (Image from Tokovinine 2013:7)

Figure 2-18: Digital scans of individual stair front-pieces that fell from original context to be reconstructed digitally with stairway model (Image from Tokovinine 2013:10)
2.3.3 Television and Visualization

Encountering high quality 3D computer graphics on television is commonplace. Cartoons and documentaries alike make use of computer graphics, no longer with the laughable effect of graphics in many late 1990s television series (see episodes of Xena: Warrior Princess for many delightful examples). The History Channel, for example, employs 3D graphics at a mind-boggling pace; often using multiple split-second realistic animations within a swelling, sensational montage (cue Ancient Aliens). Educational documentaries on television have been used to differing effect, and they often oversimplify and sensationalize topics to garner viewer interest (again, cue Ancient Aliens). This powerful medium that exposes many to their basic understanding of much of the human experience outside of their personal worldview is usually
overly influenced by the demands of advertising. The majority of any work, when looked at from a day-to-day perspective, is tedious and makes for terrible television, and archaeology is no exception. When compiled with the abstract nature of archaeological data, garnering true public interest in the process and real work of archaeology through the television audience is difficult. The inclusion of 3D models allows for a direct visual connection through interactive digital manipulation, granting a deeper connection between subject and audience (Reilly 1990).

Despite the many uses directed specifically at entertainment, several educational outlets on both cable and public television have used 3D graphics and immersive supplementary material supplied on websites to more instructionally successful ends. In one especially impressive example mentioned above, archaeologist and digital visualizer Darius Arya partnered with PBS to bring a three-part documentary series to the public that utilizes photorealistic point-cloud visualization to educate the public. Owing to the direction the show takes of allowing the archaeologist to act as narrator and expert, the perspective of the show reflects the theory and methodology used by archaeologists to interpret the built environment. As theoretical approaches shape the type of questions asked (Huggett 1995), the utilization of an archaeological perspective guiding the explanations, visualizations, and narrative of the program allow it to be a more direct conduit between the academic expert and the viewing audience.

*Ancient Invisible Cities* also utilizes a website to provide supplemental data and visualizations, including versions of the VR tours featured in the show (Figure 2-20) utilizing dense point-cloud visualizations (Figure 2-21). These work in a 2D video player straight from the web browser, but they are also viewable in higher end VR headsets when recognized from the browser. For the viewer, watching an expert guide a similar tour, then allowing personal
interaction, creates greater contextualization with the environment through spatial recognition and awareness.

As VR technology is not nearly as accessible as television and the internet, using examples like *Ancient Invisible Cities* helps explore productive ways to share elements of VR data with larger audiences and engage a wider population. Though lacking in some of the immersive benefits of VR technology, it is possible to use the same methods, collection practices, and data to create visualizations for multiple platforms.

Figure 2-20: Web-based VR content for PBS' *Ancient Invisible Cities*  
(Image from Ancient Invisible Cities 2018)
Figure 2-21: Screenshot from Ancient Invisible City's VR point-cloud render of Hagia Sophia
(Image from Ancient Invisible Cities 2018)
3 ARCHAEOLOGICAL PRAXIS

Randall H. McGuire (2008:51) explains praxis as the process of acquiring knowledge of the world, critiquing the world based on that knowledge, and then taking informed action. Understanding that knowledge is always informed and interpreted through a social and political lens is essential and creates the need for theoretically informed self-awareness in research. Archaeological praxis is founded on a strong ideal of community engagement to aid in a more accurate and holistic interpretation and presentation of the past, and this requires both education and active engagement in cooperation with the affected stakeholders to challenge system issues and create beneficial and sustainable change (Mullings 2007). This is especially poignant regarding issues of race and class, examinations of structural violence and marginalized communities, and how these processes have shaped current lifeways, ideologies, and assumptions (Mullings 2007).

Cultural heritage can play an active role in how an individual self-identifies and in creating a shared sense of identity for a group. Studying archaeology and cultural heritage is also important because learning from the past helps us improve our future (Little 2002:4). Exposure to the lessons of the past also leads to the development of critical and analytical skills, especially in the early stages of education, as students can explore how events of the past have shaped the present (Little 2002:6-7). Archaeology is uniquely suited to dispel many nationalistic and racist agendas through a recounting of evidence and truth within the past, and it also has the power to remove the political veils of historical rewriting by the prevailing power structures over time (McGuire 2008). There is also a beauty to exposing everyone to the experience of being in remote locations of the world, of seeing the Pyramids of Giza and the Great Sphinx, of visiting the Grand Canyon, or even walking on Mars. This exposure to the sheer size and diversity of the
world, especially in the K-12 years, reveals life beyond an individual’s enculturated worldview. Objects of massive scale, such as the Pyramids of Giza, are difficult to convey in 2D formats. Bringing this view through VR to the classroom, especially in marginalized communities where technology and opportunities may be limited within our educational structure, opens up the world at an age where wonder and excitement can especially shape goals and ambition. It is this type of democratization of knowledge and community engagement that I argue for at the end of this paper, though it needs to be approached through a strong understanding of theory to avoid misrepresenting the past and to mitigate any potential adverse consequences. In short, it needs to be approached with praxis.

3.1 Technology and Change:

Technological development is often seen in anthropological literature as having a deterministic effect upon the flow of people, ideas, goods, and change, especially through the lens of neoliberal development policies (Ervin 2015:75-94). This determinism comes in many forms of technological use, including standardization influences, development, energy use, and urbanization, and most often these technologies are the feature of anthropological critique on globalizing initiatives towards neoliberal agendas of development, resource extraction, and market expansion (Ervin 2015:111-133). Examples of this can be found in the work of Marvin Harris (1981), who views the technology associated with a society’s infrastructure as determining the institutional structures of relationships and thereby influencing the superstructure of that society, seen through the expression of beliefs and cultural values (Ervin 2015:10-19). Though this critique is frequently apt regarding forced globalized change, and quite necessary to include in promoting a holistic understanding of the process of cultural change, this provides an overly simplistic understanding of the role that technology plays in both
daily lives and in influencing change. Archaeological theory looks at material culture, along with the changes in the technology used in its manufacture and use, to interpret events and activities of the past. Seen in this framework, technology must be understood outside of the realm of modern globalization and must be put back into its historic concept of representing and influencing, not directing, change over time.

The use of technology does impact how we interact with each other and with the materials that become associated with daily tasks, but history reveals that this is a dialectical relationship, not a deterministic one. Human activity is bounded by obstacles, and developments in technology, whether it is a new way of chipping stone or an updated version of a smartphone, alter how individuals mitigate those obstacles. Other points must be considered alongside this understanding of technological mediation, such as an individual’s access to forms of technology, the inclusion of new forms into the individual’s habitus, and the network of associations to which new forms of technology can connect the individual. This extends the theoretical base of technological influences of change to include Pierre Bourdieu (1980) and Sherry Ortner’s (1984) agentive ‘practice theory’ and Bruno Latour’s (1986) ‘actor-network theory’, in addition to an understanding of the socio-economic and political practices that keep certain forms of technology from being fully democratized, such as explained through the historically-informed theories of globalization discussed by Eric Wolf (1982) and Immanuel Wallerstein (2004) (see Ervin 2015:40-52, 53-62, 141-146). The true power of these theoretical principals within anthropological praxis is to create opportunities for communities to harness their capacity for collective power, allowing for community members to participate in the development of their community to increase the wellbeing and living conditions of the members of that community (Kozaitis 1997).
Practice theory explains individual agency in terms of enculturated habitus, which subconsciously sets boundaries on the limitations of action (Bourdieu 1990, 52-65). As habitus is learned and it is culturally regulated, the incorporation of new forms of technology must fit into something that is internally preexisting; a need or a familiar habit must be met for the technology to be successfully adopted. Therefore, there is often a lot of resistance to change, such as seen in a GSU office environment when a new email workflow or paperwork submission regime is implemented, regardless of the new technology’s promise to improve daily tasks in the long-run. Understanding individual habitus reveals that top-down directed change, even as small as the earlier example, will be met with opposition. To introduce a new form of technology, such as Virtual Reality, into the mainstream habitus and need must be understood and respected. Ortner’s extension of this idea reveals how enculturation does not just educate a new generation, but it reproduces the practices themselves and, in effect, reproduces culture in a kind of feedback, dialectical system (Ortner 1984:144-150). For example, I was born in the last generation that remembers life before home computers and the internet became ubiquitous. This massive transition to how we interacted and worked through our daily lives was learned through various influences on my practices during the first eighteen years of my life, ranging from school, to parental influence, to personal interest. With the birth of the subsequent generation, who now happen to be many of my peers in graduate school, the process of enculturation included these new practices from the onset, invisibly and seamlessly after only a decade. In this way, Ortner’s understanding of cultural reproduction through action is demonstrated with direct reference to technological practice and innovation. When a need is met by a new technology, and the practice of using that technology subconsciously becomes included in individual habitus,
it is then reproduced through continued practice eventually culminating in a change in the society.

Latour focuses much of his writing on the culture of science, and many of his often-controversial theories are based on an understanding of what happens on the back-end of technology, especially computers (Latour and Woolgar 1986). Not only have humans outsourced some agency to the computing power of technology, now computers are able to complete complex technological functions that are beyond the capacity of humans. Additionally, the technological capacity of our tools and devices create constraints and boundaries upon our actions, though again, these obstacles are evidence of a more dialectical process as opposed to a deterministic one. In his ‘actor-network theory’, Latour examines the relationships between people working toward a common goal, such as an interdisciplinary team of researchers, and he considers these relationships in tandem with the technological and material apparatuses that mediate communication and complete other tasks that allow the researchers to achieve their goals (Ervin 2015:141-146). In this, Latour argues that these elements of technology possess their own kind of agency and are inseparable from the process of networked relations.

As Virtual Reality reflects a mediated form of technological communication from the content creator to the end user, actor-network theory is of indispensable use in understanding the power and ethical implications of this medium. The agency of the creator and the user are expressed through the content and experience, but the platform of VR and AR have themselves generated a kind of agency and a power within early adopters of the technology by providing a platform for new forms of expression and communication. Through this understanding, we can develop ethical content that adheres and respects the obstacles and opportunities created with this technology, and we can understand how it affords different collaborative, educational, and social
relationships. Additionally, as Artificial Intelligence continues to develop, this theoretical framework will continue to grow in importance as humanity is forced to establish the constraints and definitions of what we consider sentient entities. As agency is a prime component to sentience, this theory may become one of the precedents in this future debate.

3.2 Praxis and Accessibility

Accessibility is a necessary component in praxis, as it promotes engaging systemically underrepresented communities and individuals in education and community action, providing opportunities and a voice to those who are normally restricted by institutional gaps in access. Prioritizing a praxis-based approach in archaeology through community engagement, transparency, sharing, and education can provide opportunities to both the archaeological team and the affected stakeholders. For example, Emancipatory Praxis, in an archaeological context, removes both the amnesia of past people and events created by time and political pressures and democratizes the knowledge of the past, often allowing marginalized communities to claim their identities (McGuire 2008). Restorative Justice is a common theme of archeological praxis, through attempting to correct failings of the past, and as discussed above, VR and AR does have the ability to give an active voice to marginalized people who have suffered in the past. Archaeology that engages with the community in emancipatory praxis, such as seen in many of the emic views provided by ‘alternative archaeologies’, such as Indigenous, Feminist, or Critical Archaeology, provide insight into how a marginalized community attempted or succeeded to address injustice and enact change through archaeological presentation (McGuire 2008). The key here is the presentation, the action that unifies collective thought and awareness of an injustice, and this is the collective agency that can be mobilized to enact change (McGuire 2008). Not only do the archaeologists and affected communities need to collaborate as partners, but the
public needs to be addressed as well to gain that necessary component of collective agency (Kozaitis 1997; McGuire 2008). VR and AR are entertaining and informative tools to engage the public in active pedagogical techniques that can return a voice to the past and raise awareness and empathy about current issues that need to be addressed to avoid reproducing the failures of history while also identifying and learning from historical successes, often instilling a sense of community pride (e.g.,).

A praxis-based approach demands a holistic understanding of the unique circumstances of individuals within the framework of their societies, encultured belief structures, and within the modern globalized world (Kozaitis 1997). Utilizing Wolf’s (1982) view of the long-term effects of colonization, resource extraction, and marginalization in conjunction with Wallerstein’s understanding of the global neoliberal order of core, semi-periphery, and peripheral nation-states, areas of vulnerability, scarcity, and marginalization can be identified. As top-of-the-line commercial VR systems still cost around $800, this technology is not accessible to many people, even those in core countries. Understanding these areas of structural violence, neoliberal marginalization, and scarcity allow for informed decisions on where this technology would be the most impactful and how best it should be used within certain areas. Employing high-tech devices in areas that lack basic resources, much less internet access, is a misuse of resources and of little use to the population, especially long-term. Determining when and how to use this technology in educational initiatives will rely heavily on a holistic understanding of the areas that would benefit most from the educational value and capacities for collaborative participatory action research and co-directed change programs appropriate for this type of technology.

There are versions of this technology that are much more affordable, requiring a smartphone, a cardboard or relatively inexpensive plastic viewer that ranges in price from $1 to $30,
and internet access for long enough to download a few applications. As smart phone companies tend to recycle older products, and many generations of phones are now going unused, there is potential to partner with one of these companies to use older phones that have been out of service to expand use of this platform (e.g., Samsung 2018). With a focus of community outreach, universities have the ability to become the cultural brokers in partnerships with companies such as Samsung, HTC, and Apple to potentially bring these experiences into marginalized areas where students would not otherwise have access to these educational platforms. So far though, I have not seen this acted upon in my research, which is why I press for the university position described at the end of this paper to actively seek out these partnerships. Additionally, using these theories to understand and identify the use-patterns and the areas of need of emerging technological applications allows for the construction of ethical and inclusive means of overcoming obstacles and creating opportunities towards the deployment of these technologies to local stakeholders.

3.3 Benefits of Immersive and Experiential Learning through Technology

Immersive environments offer a platform for experiential learning. The value of experiential learning resonates across boundaries (Figure 3-1), as it has been shown to allow individuals of many backgrounds and education levels to interact and relate with the material due to its low degree of abstraction (e.g., Counts Jr. 2003). Combining the use of the body and the brain through experience also allows for lasting retention and encourages participation while also centering the learning foundation on informed practice over textural learning (Counts Jr. 2003). Gaining direct and diverse educational experiences can often be difficult. In school systems, resources are limited and unevenly spread, so opportunities to gain direct knowledge from field trips or expert demonstrations are not always available. Field trips, expert demonstrations, and
constructed experiences, in addition to the actual direct experiences themselves, often require costly travel and logistical problems that can be insurmountable, especially within a classroom setting. The synthetic realities of AR and VR are controlled and constructed platforms that can be individually manipulated through interaction in a manner similar to real-life educational experiences within museums and field trip visits. Though the more expensive AR and VR platforms are more expensive than field trips, smartphone-based applications or mobile VR services are examples of affordable options. VR and AR can also take students to places inaccessible to the general public, such as Mars.

![Figure 3-1: Value of Experiential Learning](image)

Technology can respond dynamically when new information emerges, allowing for more accurate representation of archaeological material. Additionally, these technological platforms often require fewer resources to develop and maintain and can be presented to larger audiences than museum installations alone can reach. These synthetic reality platforms also lack many of the resource requirements necessary for building exhibits and establishing non-damaging paths.
for tourists around cultural heritage sites. Owing to these costs, museums are repeatedly forced to represent a limited version of history from the palimpsest of the archaeological record, and due to budgetary restrictions, it is often difficult and costly to update exhibits when additional information is discovered (Stone 1997). This is also an issue that plagues documentaries, as many outdated examples are still sold and regularly aired on respected networks, thereby disseminating misinformation (Armelagos et al. 2012). In synthetic reality platforms, resources are digital, so the only resource that is necessary for updates is a skilled content creator to curate the project, though finding and maintaining funding for this has its own difficulties.

VR and AR technologies can reproduce these concrete experiences, making them more accessible through integration within educational practices. Consumer use also allows for public education, as virtual tourism through 360° video and photos are very popular forms of entertainment within VR (Felix and Paul Studios 2017). Though never replacing the experientially important social component, challenges, and complete experience of travelling, VR offers a simulation of the experience of traveling around the globe without the cost, exposing users to concepts outside of their enculturated worldview.

3.4 Praxis and Display

Displaying archaeological material inherently means removing them from where they were found, and museum display is a prime example of the challenges that come from interpreting an object and presenting it outside of its archaeological context. Museum display has been the source of anthropological criticism owing to the often-unconscious bias that comes from interpreting materials from the dominant political perspective of the institution (Lavine and Karp 1991; Stone 1997). Another concern with considering archaeological materials away from their context is the tendency to see them as disconnected, static objects, shifting the focus away
from the meaning of the object and onto the object itself (Stone 1997). This perspective can also unintentionally be applied to the representation of the people connected to the objects, delivering them as static placeholders for their time and bereft of any individual agency effectively essentializing and decontextualizing these individuals and populations (Boon 1991; Kirshenblatt-Gimblett 1998). Additionally, archaeological interpretation is constantly in flux, representing many voices, and creates difficulty when trying to establish singular objectivity (Bonde and Houston 2013).

VR and AR technologies allow for more information to be linked with the archaeological material, either through visualizing data in its appropriate context (Figure 3-2) or supplementing the material within traditional exhibit practices (Figure 3-3). Providing this bridge creates a larger network of associations between time, place, and object that more accurately represents the complex reality of the archaeological record. Both VR and AR platforms can provide a more holistic approach to archaeological presentation that, when used with a praxis-oriented perspective, can battle subconscious bias or lack of critical theory within interpretive displays.

Figure 3-2: VR photogrammetric visualization of paleolithic cave occupation in France. (Image from Realities.IO 2018)
3.5 Praxis and PCE

From its inception, PCE has prioritized transparency and sharing research with the various stakeholders within the surrounding community. As in many locations, there is a nuanced interplay between these various stakeholders, and understanding these groups and their agendas and goals enough to maintain a helpful relationship with cooperative research goals is a cornerstone of praxis. The site’s remote location offered some initial opportunities and complications, as the remote nature necessitated the help of a local guide, allowing for regular interactions with members of the community (Glover et al. 2012). However, the remote nature of the archaeological work made transparency difficult, as news of the work spread as hearsay rather than through first-hand observation by most community members. Owing to this challenge, locals often viewed the project as mysterious, steering inadvertently away from the ideals of community archaeology and praxis (Glover et al. 2012:519). This was mitigated to a
certain extent by the hiring of local workers to help at the site. Those individuals could share their experiences of the reality of archaeological work, quelling the rumors of potential looting or unnecessary destructive activities (Glover et al. 2012:519). This is only one of the examples of the benefits and necessity of working with local communities, both at the site and within region.

To this end, it must be noted that archaeologists lack many of the tools used by ethnographers, earned through living as a community member for an extended period of time, but we must make decisions that potentially affect many aspects of community life (Glover et al. 2012:516). This includes contributing to tourism that could indirectly change the economic situation, industry, infrastructure, and have a drastic effect on the population’s daily lives. In the Maya area, especially surrounding Cancun, the archaeological tourism and ecotourism industries are huge economic earners for the region, and several companies and local organizations have preexisting relationships and goals for the region associated with Vista Alegre (Glover et al. 2012:515).

Figure 3-4: Map of locations of Vista Alegre (starred), the tourist destination of Holbox, and the Maya town of Chiquilá. (Image from Google Maps)
As it is necessary to first understand the roles and interests of the affected stakeholders, one of the first goals of PCE was to identify the stakeholders and attempt to establish contact with representatives from the groups. In many cases, such as **Instituto Nacional de Antropología e Historia** (INAH), this was necessary, as obtaining permits from this federal agency must always occur prior to any research or excavation. Others were sought out to provide inclusive planning opportunities, establish invaluable local connections, and to gain as extensively holistic of an understanding as time and logistics permitted. In 2012, PCE identified the stakeholders as follows, but this list has changed greatly in the subsequent six years (Glover et al. 2012; Glover personal communication, 2018):

1) **The San Angel/Chiquilá Ejido**: The San Angel Ejido is the governing body for the local town-area, and Chiquilá is an annex of the ejido, though the city of San Angel is almost 30 km south of Chiquilá. Membership in the ejido must be purchased.

2) **The Town of Chiquila**: Chiquilá is on the water, acting as a gateway to the growing tourist destination Isla Holbox (and Vista Alegre), and the residents are a mix of local Maya and non-local Veracruzanos who moved into the area displacing many of the indigenous Maya population during the late 1970s or early 1980s (Glover et al. 2012:512). Glover et al. (2014) predicts that the tourism development within this region will increase as Isla Holbox grows as a tourism destination.

3) **Government of Lazaro Cardenas**: The municipal government of Lazaro Cardenas, with its political seat in Kantunilkin, is a major player in development related decisions along with the local government. The municipality also has more direct relations with state of Quintana Roo officials, who are another important stakeholder in development efforts.
4) Tourism Cooperatives in Chiquila are harder to define, as there are a number of individuals and groups that are loosely affiliated with Puerta Verde, and primarily make money by transporting tourist across the Lagoon, though it is inferred that their highest earning endeavor is by taking tourists to swim with the whale sharks, though they are protected by the Yum Balam (see below) (Glover et al. 2014).

5) Yum Balam, in the northern section of the Mesoamerican Reef, is a part of a larger group of study and enforcement of the protected animals and plants surrounding this area. They lack much tourist infrastructure, focusing resources on research (Glvoer et al. 2014). This protected region is part of the larger Comision Nacional de Areas Naturales Protegidas (CONAMP), which currently protects 182 natural areas in Mexico and the Mexican Caribbean (CONAMP 2018).

6) INAH provides the permits for archaeological activities in the region, and as such INAH functions to keep their national patrimony over archaeological material and is the institution that requires both project plans and reports, making working with them more of a partnership (Glover et al. 2014).

Balancing the goals and wishes of these stakeholders, especially in a world of ever-changing bureaucratic representatives and uncertain politics, has been challenging for PCE members, as it is to most archaeological projects. Differing receptions to the work of the team and differing permissions often made planning fieldwork difficult, even impossible when major equipment pieces were held up in customs (Glover et al. 2012), but these are familiar problems to archaeologists, also pointing to the importance of praxis and community involvement with our work. A proposed museum (see Glover et al. 2018b) in the modern Maya port town of Chiquilá would capture the attention of both the modern population and of visitors that travel to the city as
a waypoint toward the tourist destination of Holbox across the bay (Figure 3-4). Though still in its early inception, collaborating with a project like this would allow for a curated version of the visualization to be presented in a contextualized setting for both local and visitor consumption. The goal with this phase of the project would be to find a sustainable methodology for technological integration that could be easily maintained in an area unlikely to have the dedicated resources to provide constant technical support.

These are the same obstacles that would accompany the integration of AR into an on-site visualization at Vista Alegre. This phase of the project would need to be somewhat self-sustaining, able to function with variable internet access and technical expertise. Maintaining sustainable directed change is a foundation of the praxis-based approach, so these technological hurdles would need to be overcome to advance this project. Solutions through integrated data storage and in hand-held computing offer potential solutions to this problem, and fortuitously, the technology should converge with the timing on this project. Additionally, the potential effects of increased tourism and possible negative outcomes would need to be analyzed in order to best serve the community with the establishment of a museum.
4 SITE BACKGROUND: VISTA ALEGRE

I became connected to the Maya site of Vista Alegre through my research with Georgia State University professor and archaeologist Jeffrey Glover, whose ongoing investigations at the site provide field opportunities for students of Maya archaeology. The site is situated on a densely forested small island along the coast of the northeastern area of the Yucatan Peninsula within the Holbox Lagoon (also referred to as the Yalahau or Conil Lagoon) (Figure 4-1). The modern town of Chiquilá, the closest to the site, is approximately 7.5 km west and acts as the transit hub to the nearby tourist destination Holbox Island. The only way to access this island for the research team is to charter a boat from Chiquilá and travel for about half an hour through mangrove and estuaries to arrive at the site. The isolated nature of this island makes it a good candidate for digitalization to allow for remote viewing of the site.

Figure 4-1: Map of Vista Alegre and surrounding area
General location of Yalahau Lagoon shown in inset (Image from Google Earth)
Figure 4-2: Site map of Vista Alegre showing locations of major structures and features.
Map by Jeffrey Glover, 2017.
The area of the island is approximately 6 ha, measuring approximately 385 meters east to west and 630 meters north to south, and originally revealed 27 structures mapped during a 2005 FAMSI funded project by Jeffrey Glover and Dominique Rissolo (Glover 2006:556). The most recent interpretations of the site reveal a current total of 40 structures and features (Figure 4-2) after field seasons occurring in 2008, 2011, and 2016 (Glover et al. 2018a). The data used in the reconstruction of VA/VR are derived from this initial mapping survey and subsequent field work at the site as a part of the INAH approved Proyecto Costa Escondida (PCE), including the 2005, 2008, 2011, and 2016 field seasons. In addition to the 40 main structures of the island, a wall measuring about 5 m wide and 2 m tall at its highest point, bisects the island running east/west (Glover et al. 2018a). Another feature, a smaller 1 m wide andador, or walking path, extends south c. 1.4 km from the southern portion of the site, terminating at a collapsed temple on the mainland dubbed “Templo Perdido” (Glover 2006; Glover and Rissolo 2010). This mainland area will not be included in the first version of VA/VR, but it does present an intriguing direction for expansion.

Over a decade of research has revealed that the site was most likely of importance for circum-peninsular long-distance trade, based on its location and the artifactual assemblage recovered (Glover et al. 2018a). The apex of the site’s use and importance appears to occur during the Late Classic and Terminal Classic periods (specifically during CE 750/800-1050/1100), though occupation can be traced from the Middle Preclassic (c. 800/700 BCE) period through the Historic period (Glover et al. 2012).

4.1 Research Background

In 1954, Vista Alegre was first visited by William Sanders, who collected some ceramics from the surface and excavated four test pits. While completing a survey of the Yucatan coast
during the mid-1970s, Jack Eaton next visited the site, commenting on its obscuring overgrowth (Glover 2006:555). During the mid-1980s through the mid-1990s, the site once again was visited by archaeologists; this time a team of researchers investigating the role of the Yalahau Lagoon in coastal trade studied the island (Glover 2006). In 2002, Jeffrey Glover, Dominique Rissolo, and Byron Kirkpatrick visited the site as a part of an exploratory trip, taking notice of a particularly intriguing monument depicting a highly eroded carved serpent head that had clearly been moved from its original context (Glover 2006). This find propelled questions leading to the FAMSI funded 2005 field season that led to the subsequent phase of fieldwork and the formal creation of the Proyecto Costa Escondida (PCE) “to investigate the pre-contact and historic maritime cultures and landscape of northern Quintana Roo, Mexico” (Glover et al. 2012:511), which increasingly pointed to the significance of Vista Alegre as a center for maritime trade.

Beyond the initial 2005 survey season, three other field seasons focused on excavations and continued survey work at Vista Alegre in 2008, 2011, and 2016. After realizing the site’s potential contribution to maritime trade studies, excavation data became necessary to assess the site’s function as a port and occupational chronology (Glover and Rissolo 2010). The subsequent 2008 season aimed to further explore this goal through excavation and survey to address three research questions: 1) examine the lived daily experience of the inhabitants and their change over time, 2) determine how the site fits into the interactions of the Yalahau region, and 3) define Vista Alegre’s role in a circum-peninsular trade network during the Terminal Classic and Postclassic periods (Glover and Rissolo 2010). The survey component of this season filled in areas of the initial survey that needed better documentation, such as areas between the site and the nearby Templo Perdido, though a delay in customs limited the use of the Total Station for extensive mapping, and reconnaissance was conducted in search of potential water
sources (Glover and Rissolo 2010). Six excavation units measuring 1 m² were dug in areas that were away from structures, to avoid damage, but close enough to areas that seemed as though they may provide a high yield of archaeological material based on surface finds and relationships to platforms (Glover and Rissolo 2010). Three of the units surrounded Structure 1, the main pyramid, and the other three were placed in areas that appeared to hold activity or potential middens (Glover and Rissolo 2013:31). Analysis of the archaeological material recovered suggests that the occupational history of Vista Alegre seems to differ from the surrounding Yalahau region, pointing to its importance in maritime trade (see Glover et al 2018). Though the existence of a highly populated ancient Maya port was not evidenced, mainly owing to the size of the island, enough information and material was gathered during this season to plan a strategic follow up season to better understand Vista Alegre’s role within the maritime trade network and a tightening of the occupational chronology (Glover and Rissolo 2010).

The 2011 field season focused on three main goals: “1) the reconstruction of the coastal environment through a program of estuarine cores, hydrogeochemical sampling and coastal classification of ecological zones, 2) the extension and completion of excavation units outside of
smaller structures that began in 2008 in Vista Alegre with the approach of recovering known human remains, and 3) a study of the historical sites associated with the north coast” (Glover and Rissolo 2013:1). Though the implications of a more holistic ecological understanding of the site informs many of the project’s interpretations, the primary goal is understanding the daily life of the population of Vista Alegre through changing environmental conditions and resource pressures. The PCE research team expanded to include many interdisciplinary experts from the fields of coastal ecology, geo-archaeology, and hydrochemistry, and the approaches used to collect data included underwater coring, continued mapping of surrounding structures, and further excavations. Underwater sediment cores were collected from 12 locations around Vista Alegre and analyzed jointly by Beverly Goodman and Rohi Jaijel, revealing changes in the sea level over time (Glover and Rissolo 2013:20-26; see Jaijel et al. 2018).

The goal of the excavations was to finish Units 6 and 7 and pursue excavation of the human remains found in the northern portion of Unit 5, leading to the excavation of Units 8 and 9 to fully excavate the remains (Figure 4-3) (Glover and Rissolo 2013:31). Obsidian, bone, sediment, and other archaeological materials were examined in depth from the excavations, though the vast majority of collected material were ceramic or mollusk shell. Coastal ecologist Derek Smith joined the project to aid in examining the mollusk shells to corroborate coastal sediment data regarding climate change in the area (Glover and Rissolo 2013:7-12). The bones and teeth of the human remains were analyzed by Dr. Vera Tiesler at the University Autonoma de Yucatan in Merida (Glover and Rissolo 2013:115-134).

The reconstruction of the paleoecology of the coast during this season revealed a changing paleocoastline over the past 3000 years and how that might have affected access to freshwater at the site over time (Beddows et al. 2016; Jaijel et al. 2018). “The same constant
movement of water often creates a path for cultural dynamism - bringing together people, ideas and goods from a much larger area than is typical of inland places”, Glover and Rissolo (2013:179) note, while also stating that “we recognize that neither environmental nor social factors alone explain the complex decisions and actions (and their material correlates) of the people of the past, as they continually (re) constitute society through their daily practices.” The importance of this contribution led to the inclusion of environmental data into the core research mission of PCE, recognizing environmental change as instrumental in understanding the dynamic symbiosis between people, place, action and interaction (Glover and Rissolo 2013).

Figure 4-4: Location of Vista Alegre in northern Maya lowlands
Shown among other identified sites (Image from Glover and Rissolo 2010)

After a successful 2014 PCE excavation of the nearby populous center of Conil (Figure 4-4), members of PCE realized that the research for both sites was complimentary, and the 2016
season focused on the connections and trade relationships concerning these closely linked sites (Glover and Rissolo 2015). The primary objectives for the 2014 Conil season were “1) complete a reconnaissance of the Conil site using advanced geospatial technologies, in combination with traditional methods to begin to determine the size of the community, and 2) conduct a test well program to provide a basic understanding of the history of the site (adding to earlier excavations by William Sanders in the 1950s)” (Glover and Rissolo 2015:2). The main pyramid structure of Conil was one of the largest structures on the Yucatan’s northern coast during its primary fluorescence, during the Late Preclassic, which does not correlate with the height of Vista Alegre (Vista Allegre III), during the Late Classic to Terminal Classic Periods (CE 740/800-1050/1100) (Glover and Rissolo 2015:97). One interpretation is that during the Postclassic, inhabitants of Vista Alegre abandoned their site and inhabited Conil (Gentil 2017:46-47). Additionally supporting the connection, “both sites are separated by only 7 km, were not continuously inhabited over the past three millennia and their occupational histories do not resemble one another. This history of episodic settlement provides the keys to understanding the vulnerabilities and resistances of the people of the coast” (Glover and Rissolo 2015:97).

A DJI Quadcopter “drone” and an unmanned fixed-wing airplane aided in completing the survey quickly, generating images for photogrammetry. “The Conil site was documented with a total station in a period of two weeks, while the aerial scan for the SFM data was done in one day, highlighting the utility of large-scale mapping in a short time with SFM”, Glover and Rissolo (2015:36) concluded, remarking on some of the benefits of this technology. Verna Gentil (2017) returned in a later season and contributed much to our understanding of Conil’s settlement pattern as part of her master’s thesis.
Returning primarily to Vista Alegre during the 2016 field season, the team had the following research questions: 1) how much has the coastline changed, and to what extent was this caused by natural and/or human modification?, 2) what role does drinking water play for the coastal inhabitants, and how did this change over time?, 3) how do seasonal variances in resources apparent today compare with the archaeological evidence, and how were these
variance mitigated through time?, and 4) what was Vista Alegre and Conil’s involvement in broader economic networks? (Glover and Rissolo 2017). To research these questions, PCE identified three objectives: “1) The reconstruction of the coastal environment through an expansion of the sediment core program; 2) an excavation program in Vista Alegre; and 3) continue working on the Conil map and continue with the test well program outside of architectural contexts,” though extenuating circumstances prevented the team from completing some of the intended projects during that field season (Glover and Rissolo 2017:1-3). The main work that was completed during this season at Vista Alegre were Operation 1, the analysis of evenly spaced test units to determine the extent of the anthropomorphic modifications of the island and to better understand the extinct environment (Figures 4-5 and 4-6), and Operation 3, the excavation of several domestic platforms (Figure 4-5), in addition to a successful coring campaign. After the 2016 season, the resulting Informe, or publication to INAH after a field season, was the first from PCE about Vista Alegre to embed 3D imagery into the documentation (Glover and Rissolo 2015:59).

Recently, the public face of the project has been growing. For example, a Canadian publication featured the site’s role in trade and created an effective reconstructive illustration of the site for the article (Figure 4-7), accurately depicting the site mostly bare of trees, though the scale of the site was probably less grand than illustrated (Glover, personal communication 2018). With the addition of a proposed site museum in the nearby town of Chiquilá, Vista Alegre and the work of PCE is positioned to reach a wider audience (Glover et al. 2018b).
The fieldwork conducted intermittently over the last thirteen years of researching Vista Alegre has been extensively multidisciplinary allowing for a variety of research questions to be addressed. Hydrology, geoarchaeology, ecology, GIS, community involvement, survey by land, drone and canoe, ceramic analysis, test unit and trench excavation, floral and faunal analysis, and a variety of laboratory analytical methods have all been utilized to record and interpret this site. While the initial focus of research at Vista Alegre centered on the use and importance of the site, subsequent research reveals interaction spheres extending to Chichen Itza and Coba, in addition to strongly connecting it of several other local sites, namely the “Templo Perdido” structure mentioned above, and even more importantly, the large site of Conil\(^2\) supporting a sizable community close to Vista Alegre (Glover and Rissolo 2015). The site has revealed deep cultural and environmental significance for the understanding of Maya port and trade activities, in

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\(^2\) This connection offers another interesting area for future expansion of the VA/VR project; as these sites are further investigated, their relationship with Vista Alegre can be represented within the model, both spatially or as adding the experience through gamification of the connections.
addition to revealing qualifiable changes in the dynamic coastal environmental factors and equally dynamic reactions by the site’s past inhabitants.

4.2 Interpreted Site Chronology

Though the simulation created for this project will only focus on the apex of building, a key feature of VA/VR is the ability to show different phases of occupation and change over time, so understanding the chronology of the site is necessary background information to consider for extending the project’s scope to its full potential. Recent work (Glover et al. 2018a), utilizing ceramic data to corroborate the shifting trade patterns associated with Central Mexican obsidian, has established the most recent chronology for the site used in this project. Utilizing the data collected and interpreted over many years of fieldwork, the following chronology has been proposed for the site, beginning with early occupation during the Middle Preclassic and extending through the Historic era.

4.2.1 Vista Alegre I (800/700 – 400 BCE)

The first settlers of Vista Alegre seem to have most likely originated from the Peten-Belize area of the southern lowlands owing to the style of pottery found at the site, and interestingly, Vista Alegre is the first example of this direct population movement and an unexpected development not represented in current models (Glover et al. 2011). As the ceramics remained recognizable to original style, it would seem reasonable to look to this era for stylistic standards for their architecture to inform the representation of this phase in VA/VR, and as an added challenge, these architectural elements were likely constructed or finished with perishable material. Though the project will currently only represent a reconstruction of the site at its apex, adding the other phases is a top priority for future expansion of this project, but will be admittedly limited by the archaeological data.
4.2.2 Vista Alegre IIa (75 BCE -CE 400/450)

The roughly 300 years between Vista Alegre I and Vista Alegre IIa is the topic of some mystery. Ceramic analysis reveals a possible episode of depopulation, though Glover and Rissolo (2010) also offer the possibility of sampling. Vista Alegre IIa, however, shows clear evidence of a productive settlement, connected with both inland neighbors through shared ceramic styles, but also showing evidence of connections to wider social spheres and early trade. (Glover and Rissolo 2010:138). Common ceramic styles were shared with principal inland sites thriving at the time, such as Kantunilkin and Naranial, among others; however, some ceramic styles were not found inland but came from the area to the south. As with Vista Alegre I, reconstructing this period will be a future goal for this project and will use recent surveys of Conil to better understand the relationship between these two sites (see Gentil 2017).

4.2.3 Vista Alegre IIb (CE 400/450-700)

Ceramic styles from Vista Alegre IIb point to a continuously occupied site tied closely into elite interaction networks through merchants and trade (Glover and Rissolo 2010:138). Around CE 400, there is evidence of sea level rise and abandonment of most of the inland sites of the Yalahau region, but ceramic evidence from Vista Alegre reveals lower percentages of ceramics dating to the late 6th and early 7th centuries, pointing to a declining population with complete depopulation between CE 700 and 750/800 (Glover et al. 2018a). Though not a current priority, this stage would be fairly easy to modify owing to its stylistic continuity from the Vista Alegre IIa phase.

4.2.4 Vista Alegre III (CE 750/800-1050/1100)

As this period marks the fluorescence of the site, it is the structures and topography of Vista Alegre III that will be represented in VA/VR. This period began after an occupational
hiatus of approximately 100 years, and the origins of this new groups of settlers is uncertain, 
 though ceramic evidence points to the new settlers having a strong connection to Chichen Itza 
 (IIIB), likely those originating from the coastal-spanning western region of Chikinchel, such as 
 the population evidenced at the site of Emal (Glover and Rissolo 2010:139-140). Chichen Itza 
 was a prominent, conquest minded city that rose to power during the Terminal Classic and 
 utilized many northern Yucatan coastal cities for salt production and as traded hubs, and current 
 interpretations of the ceramic assemblage of Vista Alegre not only reinforce the strong 
 connection to Chichen Itza, but many unique examples point to extensive interaction beyond the 
 reach of many other Chichen Itza -associated territories (Glover and Rissolo 2010:139-140; 
 Glover et al. 2018a). The site was clearly embroiled in the Chichen Itza socio-political sphere, 
 and as the political center began to decline, Vista Alegre and the other sites reliant on that 
 network, also suffered depopulation (Glover and Rissolo 2010:141).

Clearly, stylistic similarities can be drawn from the areas of Chichen Itza, where 
 extensive archaeological work and preservation has been achieved. This provides much of the 
 aesthetic data from which the structures in VA/VR are crafted. Additionally, the similarities 
 with the western regions can be mined for stylistic similarities (Glover and Rissolo 210:140).

4.2.5 Vista Alegre IV (CE 1100-1521)

After the depopulation during the end of the Terminal Classic or early Postclassic 
 periods, hastened by the decline of Chichen Itza, ceramic evidence points to the use of Vista 
 Alegre as a pilgrimage location, and the nature of its potential use and connection with the 
 populous site of Conil at the time still needs to be explored (Glover and Rissolo 2010:141). 
 Glover and Rissolo (2010) have also proposed that the inland site of San Ángel may have been 
 linked to the northern coastal sites via the Sabana Zanja, a wetland potentially used as a regional
travel corridor, at this time. Once the archaeological understanding of this phase has been expanded, it would provide a very interesting era to digitize for VA/VR as the landscape takes on a sacred use for outside populations. Recreating this experience would provide a compelling framework from which to experience the Postclassic occupation of the site and the broader trend of constructing and visiting coastal shrines.

4.2.6 The Historic Era (CE 1552- present)

The Contact period spanning into the modern era obviously represent times of great change, destruction, and massive daily upheaval for indigenous residents. From the initial conquistadors and annexation by the Spanish Empire, dozens of internal and external wars have created a nuanced and often tumultuous modern political system, requiring much more attention than this project can currently produce. It is important to have an understanding of the events leading up to the establishment of the state system within Mexico, and the unique situation of the predominantly indigenous Maya in Quintana Roo and the Veracruzano majority of Chiquila is helpful to understand the current stakeholders and power struggles currently rippling through the social and political network of the region (see Section 3.5 for further discussion).

4.3 Relevant Feature Descriptions

As this project focuses on the visual reproduction of the site, most of the necessary data are in the form of descriptive analysis of specific features and their associate quantitative measurement data. Utilizing collected observations from previous field work and a personal site visit, the following section delineates the primary physical details utilized to create the aesthetics of the feature models used in VA/VR, primarily concentrating on details for the 40 main structures and features. Most of the data for this section was collected from the Glover’s doctoral dissertation, the analysis of the six excavation units dug during the 2008-2009 field
season, and the results of the two excavation operations conducted during the 2016 field season (review Figure 4-2). Unfortunately, time constraints for this project permitted that the model only feature specialization for the major features discussed in the following sections, primarily focusing on the main complex to the western side of the island, owing to the prominence of the architecture. Additionally, “[t]he western margins of the site are of particular [archaeological] interest since it seems that in them the physiography of the island was significantly transformed by the ancient inhabitants of the site” (Glover and Rissolo 2013:180). For this first project phase, basic placeholder buildings maintaining their accurate volumetric and geographic space will be used for now, allowing for future versions of this project to add detail as time permits.

4.3.1 Structure 1:

Standing 10.7 m high, this very steep pyramid (Figure 4-8) is the site’s tallest and measures approximately 27 meters north to south by 24.5 m east to west, and the north side of the structure faces the site’s principal plaza (Glover 2006:555). Owing to the collapsed state of
the structure, it is challenging to determine Structure 1’s connection with Structures 2 and 3. They may have been attached or independent structures, but in their current state it is difficult to delineate their boundaries (Glover 2006:555-557). Structure 1 additionally has a 1 m tall extension off the southeastern corner measuring 10.5 m north to south and 8 m east to west and serves an unclear function. The upper portion of Structure 1 is rounded, and Glover (2006) points to structural similarities of this portion with the pyramidal structures featured at Chunyaxche / Muyil and Tanchah (Figure 4-9). As no masonry structure is evidenced at the top of this structure, and owing to its panoramic views, Glover (2006) interprets the use of this structure as being a landmark for travelers and a lookout over the surrounding territory with a small perishable structure at the top, similar to modern palapas (Figure 4-10). A wall extends 2 m from the north side of Structure 1, and then abruptly ends, which may point to the existence of a small single chamber room at the base of the structure extending east of the wall (Glover 2006:559). This would resemble the extension in El Meco (Glover, personal communication 2018).

Figure 4-9: Muyil, Structure 8I-13, Castillo
May have many similarities to Structure 1 at Vista Alegre (Image from Zwegers 2013)
The serpent head monument was initially found at the base of Structure 1, but this location was not its original context (Glover 2006). Traditional Maya architectural uses of serpent heads were either as balustrades ends or tenoned at the corner of building walls (Figure 4-11). Glover (2006:260) interprets this monument to have originally been at the end of a balustrade, such as seen in Chichen Itza, owing to its relatively large size, heavy weight in comparison to the walls, and lack of tenon. It is likely then, if this was a balustrade end, that this was a part of a pair.
4.3.2 Structure 2

Structure 2 and Structure 1 share a collapsed section on the west side of Structure 1, making it complicated to determine the delineation or unification of these two structures originally. Structure 2 measures 77 m east to west and 40 m north to south, making it Vista Alegre’s most expansive structure (Glover 2006:561). The line drawing representing the structures (review Figure 4-2) shows the outermost extent of Structure 2’s footprint; however, Glover (2006) notes that the area slopes downward to the west and could have been tiered or featured stairs. These differences are reflected in the TIN elevation data used to create the foundation for this model, as it shows a restricted inner surface for Structure 2 when compared with the line drawing (Glover 2006:561). A heavily damaged linear superstructure (Structure 2a), measuring 7 m east to west and 27 m north to south, extends up from the eastern section of the structure, measuring 4 m at its tallest point. The southwest corner of Structure 2 extends in a wide L-shape with a 30 m east to west terrace stretching from the eastern side. Feature 7 is located at the northwest corner. Measuring 15 m east to west and 16 m north to south, it may be associated with Structure 2, though it is poorly defined and less than 1 m tall.

4.3.3 Structure 3

Structure 3 has preserved very poorly owing to its construction material, and on its western side, it almost merges with Structure 1 owing to partial collapse (Glover 2006:262). This makes the east to west dimensions problematic to measure, though it appears to be approximately 8 m with the north to south measuring 8.5 m, and the structure is approximately 3.5 m from the ground, or 3 m from the principal plaza surface (Glover 2006). A 10 m long, low collapsed wall extends from the eastern side of Structure 3 and connects with Structure 5, together forming the exterior of the main plaza. Additionally, a small 7 m by 7 m room seems to
exist on the southern side of Structure 3, supported on the north by Structure 3, the west by Structure 1, and the south and eastern sections by two collapsed low walls featuring a 2.5 m corner entrance to the room (Glover 2006).

During the 2008 field season, Unit 3 was placed just southeast of the junction between Structures 1 and 3 to search for refuse from the buildings activities to help identify its use, though reports reveal that tree roots caused major disruption during the excavation (Glover and Rissolo 2010:30). This resulted in lots of Chen Mul Incensario fragments that are associated with the Postclassic ritual use evidenced at Structure 1 (Glover and Rissolo 2010). During that same field season, Unit 2 was excavated just north of Structure 3 with the purpose of identifying plaza floors, which aids in understanding the occupational timeline for the site. This plaza floor was located along with lots of subfloor fill, and it is a future project goal to open up a larger unit to see how far the subfloor goes (Glover, personal communication 2018).

### 4.3.4 Structure 4

Standing less than 1 m high in the middle of the principal plaza, Structure 4 measures 5.4 m east to west and 5.2 m north to south. Owing to its prime location, this may have used as an alter or shrine, but the structure’s center has been damaged and Glover (2006) emphasizes that this can only be speculated.

### 4.3.5 Structure 5

Structure 5 stands less than a meter tall, measuring about 4 m east to west and 10.5 m north to south, and is also poorly defined, however, it does clearly connect to Structure 3 by the thick wall described in Section 4.3.3 and forms the eastern demarcation of the primary plaza (Glover 2006). The plaza appears to have only one entrance along the northeastern corner formed by Structure 5 and Structure 6 (Glover 2006:563).
4.3.6 **Structure 6**

Forming the northern edge of the principal plaza, Structure 6 appears L-shaped and connects to Structure 2 from the northwest corner with a wall similar to the one connecting Structures 3 and 5. The southern side of Structure 6 sits .5 m from the plaza floor and this raises to 1.5 m above the ground on the northern side away from the plaza. The north to south measurement varies from 7 m to 2 m, and the east to west measures approximately 21.5 m.

4.3.7 **Structure 8**

Structure 8 measures about 7 m on a side, ranges from 1 m to 1.5 m in height, and is located southeast of the primary building complex surrounding the plaza. The center of the structure has been damaged, and not much work has been done to further identify the usage of this structure (Glover 2006:564).

4.3.8 **Structure 13**

Structure 13 is a two-tiered platform north of the principal plaza, and the tallest portion of the higher platform has been badly damaged. This section measures 24 m north to south and 34.5 m east to west, and just west of this is an extension, raising from a ground-flush south end to 1 m tall on the north end and extending 10 m (Glover 2006:567).

In 2015, a unit was excavated 8 m south of Structure 13, an area that occupies the highest natural terrain of the site (Glover and Rissolo et al. 2017) and reached a depth of almost 4 m. Structure 13 was also one of the structures chosen for architectural excavations as part of Operation 3 in 2016.
4.3.9 Structure 14

Just west of Structure 13 is a low platform, less than 1 m tall and sometimes consisting of a single course of stonework. The platform measures between 9 m and 11 m north to south and about 29.4 m east to west (Glover 2006:567).

4.3.10 Structure 15

Structure 15 is another 1 m low platform that has a northeastern corner that is intact. It is clearly grouped with Structures 13 and 14 and measures 18 m north to south and 16 m east to west.

4.3.11 Structure 16

Owing to the location of the modern boat channel used to arrive at Vista Alegre, Structure 16 is the first one encountered by current visitors to the site. Glover (2006) contends that this position, at the northwest corner of the island, points to its use in the administrative and logistical function of handling trade goods and merchants. The platform measures 24.5 m east to west and 18 meters north to south, and it is 3 m tall at the north side and 1.25 m to 1.5 m tall on the south side. Evidence of a badly damaged, 2 m tall superstructure can be found on the eastern portion of the basal platform (Glover 2006:568).

4.3.12 Structure 17

This low mound was marked using approximations on the map. It is associated with the modern palapa and doesn’t have much detail to document (Glover 2006:569).

Though there are many other structures of interest at Vista Alegre, especially Structure 21 with intact column drums and Structure 27, and these will be added in the next phase of project development after the completion of this thesis.
4.4 The Extension of Background Research

There is always more information to explore when approaching any archaeological project, and nothing compares with first person site experience. Meeting the stakeholders, when possible, and interacting with the community during daily life cannot be replicated on paper or even in VR (yet), and this experience and connection with the community is essential to a praxis-based approach. Though I have been with the project since 2015, I have only been able to spend approximately fifteen days in the communities surrounding Vista Alegre and the site. Owing to various impediments, both political and personal, I have only made it out to the physical site once. To continue this project and its extension into a community museum, I must spend more time in the area to better understand the goals of the stakeholders and the potential impacts of including various iterations of VA/VR within the museum. A sustainable solution that addresses the educational needs of tourists and, more importantly, local school children who could gain a connection to a site local for them.
5 MODELLING METHODOLOGY AND LIMITATIONS

Visualization is essential to both the analysis and presentation of archaeological material for many reasons, including the spatial nature of the data. We are not only attempting to understand the history, use, and construction of objects or buildings, we strive to tie these into the greater context of time and place to add to our interpretations of the lives of past people. Additionally, descriptions often reflect culturally constructed assumptions and associations, leading visualizations to provide more representative versions of the archaeological material. Through using more sophisticated technologically-based visualizations, we are not only able to engage in the interpretation of this material in new and informative ways that offer a better understanding of the lifeways and relationships of people in the past but are able to turn this enhanced scholarship into a more immersive and enjoyable educational tool for the public.

As with all forms of visualization, understanding the audience and the purpose of the deliverables directs the content, methodology, and structure. Visuals for academic reports, field notations, or public consumption differ in form and function. One of the benefits of digital forms of visualization, such as 3D models and mapping, is that they can be stored and altered in multiple versions and reused for many purposes. As time is always a valuable resource to researchers, and academic careers tend to value publication over public outreach (e.g., Kozaitis 2013), digital resources allow for multiple applications of visual data to be quickly repurposed for both academic and public education. These digital features, or assets as they are called in the computer sciences, also function as a potential digital archival method that can record objects photo-realistically from all angles, allowing for preservation and further interpretation to be maintained with less handling of the original sensitive archaeological materials (e.g., Mudge et al. 2008). Digitized artifacts can also be set within their digitally modeled context, mirroring the
archaeological context that is so important to interpretation. Metadata, or data about data that is encoded with digital files, act as a form of archival contextual information about the location, time, associations, or any fields of information that are deemed pertinent (e.g., Miller 1999). Placing objects and features within their original context is also a powerful and dynamic pedagogical tool for the public, as it creates concrete networks of connections between people, objects, and places through time.

To create a viable, research and praxis-based archaeological model for a VR experience, it is necessary to think broadly, ethically, and holistically about the uses of the visualization. Creating an immersive experience requires unique thinking for visualizations, as more aspects of sensory input must be considered. These avenues also allow for new forms of interpretation with the VR frameworks through view-shed, spatial access, and the study of acoustics in ancient spaces (e.g., Vadala 2009; Goodwin and Rissetto 2017), and as the technology improves, more forms of sensory engagement will be replicated. Constructing a digital model with attention to potential applications of archiving, preservation, interpretation, and both academic and public preservation creates a sustainable, educational, interpretive, and archival platform.

5.1 Background

Even within the VR framework alone there are many approaches to the creation of immersive archaeological experiences, as discussed in Chapter 2. Some approaches, such as Google Earth VR, use a combination of point-cloud based elevation modeling and digitally stitched photospheres. This method of preservation and restoration generally favors photogrammetry and laser scanning in image creation, as these represent photorealistic models, such as the digital preservation methods used by CyArk in creating a database and of 3D UNESCO site models and presenting these in a website that is accessible to the public (CyArk
2018). Though this method lacks an interpretive reconstruction, photospheres can be effectively used for virtual tourism, public education, and remote object interpretation. The MayaArch3D project, combines a virtual tour of the site through photospheres (review Figure 2-12) with 3D modeled structure reconstructions that can be viewed in a web browser (review Figure 2-13). The project also connects these visualizations with WebGIS interactive mapping, an archaeological database, and 3D object scans of the stela and larger features that are still at the site (MayaArch3D 2017). Though the project website does not yet have the ability to view these 3D assets in a VR environment, many of the elements for immersive visualization are already constructed. The assets from this project are also used by the team in a VR environment for interpretive work (Richards-Risseto 2013), and due to the interconnected and multi-platformed design of this project, it will be easily adapted for public consumption through the project website when the technology advances to allow for WebVR, though owing to loading issues for sections of the MayaArch3D site at the time of writing this thesis (November 2018), I am not able to report on any progress to this end.

![Figure 5-1: Spatially oriented sitemap in game engine to create virtual reconstruction](Image from Vadala 2009)

Others seek to recreate a more holistic 3D view, reconstructing the site as it would have been at the time of its use. Jeffrey Vadala (2009) and Heather Richards-Risseto (2013, 2015)
used measurements from their individual sites to replicate them using 3D modeling software. Generally, in this style of constructed modeling, GIS data provides the topographic information for the natural and built environmental, which is modeled in modeling software and textured with period-appropriate vegetation or high-resolution satellite imagery, if appropriate. As GIS data are used, the locations of structures can be determined. Combined with measurements, photos, and contextual data taken on the ground of the existing structures, a digitally sculpted interpretive model can be placed in an accurate location (Figure 5-1). This same process can be used to outline locations of streets, water sources, walls, and other archaeological data which can be mirrored with well-researched digital creations. Weather, celestial positions, and wildlife are just a few of the other elements that can be modeled from site data, and these immersive environments appear spatially seamless within the VR framework. The experience of being in the site, though obviously depicted as a 3D animation, is a powerful tool for education and interpretation as it engages senses in more intuitive ways (Figure 5-2).

![Figure 5-2: 3D modeled site using GIS data for accurate structure location as seen in this recreation of the skyline at sunrise (Image from Vadala 2009)](image)

As with all reconstructive interpretations, this approach has many strengths, but questions of accuracy and assumptions must also be addressed (Kantner 2000; Klynne 1998). For example, I was a member of Georgia State University’s interdisciplinary Student Innovation
Fellowship, and we have been working on a 3D reconstruction of the blocks surrounding the university as they appeared in 1928 Atlanta (3D Atlanta 2017). I joined this project in its fourth year, realizing that the intended audience and goal of the project was for the public and not for quantitative research. As this is a educational experience and not designed as a technical method, the aesthetics of the experience were chosen for representation over the authenticity where there was missing data; preserving the experience became paramount. My goal with the project was to contextualize the visual elements that are accurately built, and to link these assets to a contextual database that allows for the object to be viewable within a browser window. Everything in the simulation is modeled from photographs, maps, and patent data that we have from the era. The team individually models the buildings, signage, streets, lights, and other elements using 3D animation software, such as Blender. Once these features are created, they can be stored as 3D objects in a visual repository and database. Though based off historic maps, large gaps in data result in ‘dummy buildings’ that are stylistically accurate but lack historic value. As we gather more information through our research of this era of Atlanta history, we replace the ‘dummy’ buildings with accurate models, also linking them to the database. In my experience, the most effective visualizations have found a way to link all of these methods together as separate but interrelated experiences.

It is important to note that this form of constructed 3D modeling provides a visually didactic function no less important than quantitatively based point-cloud representation, as both represent methods of conveying information. Archaeology is inherently an interpretive science, so reconstructive visualizations will always be the result of these interpretations. The medium and methods chosen for visualizations should ideally reflect the research questions proposed and the intended audience. In the case of VR site reconstructions, gaps in the models owing to lack
of data would take away from the experience; therefore, a more consistent experience is preferred to provide the experience that creates the maximum relationship between the space and the audience.

The background data necessary for the first phase of this project is detailed in Chapter 3. For a visual database model and user interface, I have turned to historical librarians and the digital humanities to find a way to archive and present visual, spatial, and contextual data. Digital archives have been in use for decades for a variety of logistical purposes, such as linking spatial data with images of materials on display, on loan, or in storage within a collection. Virtual displays are more frequently being used by museums and other collections as ways of drawing in the public or providing access for research. Omeka (Roy Rosenzweig Center for History and New Media 2017), a collections management tool, offers database integration, spatial management, and a website for users to interact with. We are currently developing a 3D viewing plugin for the Omeka platform for use in the 3D Atlanta project, and we are creating a plan to integrate WebVR. This same display methodology is used with the Vista Alegre project as well, as it offers enumerable benefits to both contextualizing presentational information and interpretive research. Owing to time constraints, the completion of a database has not been possible for this project, through it is integrated into the future plans.

5.2 Methodological Steps

There are many ways to go about creating 3D visualizations of an archaeological site, though each site will offer its unique challenges making certain methodologies preferable for each case. Vista Alegre, the site of the VA/VR project, has dense mangrove coverage around the island’s margins, and the island is further obscured with a concentrated upland forest. Owing to this, most of the applications discussed in this project will pertain to the restrictions created by
this dense foliage coverage. This makes the use of point-cloud generation difficult to produce site-wide, as the dense tree coverage would impede data collection, so for this project, I am choosing to primarily use 3D modeling.

Despite the different methods of collecting and manipulating data, which are discussed further below, there are some basic requirements for creating an accurate 3D visualization of an archaeological site. First, it is very important to have the archaeological knowledge and research background to accurately represent the site. This can be achieved through working in familiar areas, or through the extensive reading and preparation for each new visualization. This knowledge is essential to a praxis-based approach. Second, an elevation map of some kind needs to be digitized in an editable form for GIS, either through Esri’s ArcGIS or an open-source platform like QGIS. Survey data, typically from a total station, is needed for all features that are going to be included in the visualization, such as walls, buildings, or courtyards. This provides the foundation for the model to create accurate topography and locational data.

With this foundation in the existing world, recreations of the past can begin. The second necessity is access to 3D modeling software and the skills to use it. There are many options for this ranging from free open-source software, such as Blender, to more intuitive paid versions, like the often-used Sketch-up\(^3\). Esri provides tools as well in their 3D Analyst extension and ArcScene that can meet some of these needs as well. Fourth, there needs to be some textural data for the site, usually gathered through photos or video. This will provide the visible colors, textures, and detailed information about the landscape and features. Finally, a platform to display the rendered visualized product needs to be decided, with 3D applications ranging from

\(^3\) Though educators can request one free license from Sketchup or request that their institution purchase networked licenses, the current student rate is $49 a year (see http://www.creationengine.com/html/sketchup.html for pricing in the United States at of 2018).
web-based interfaces to full VR immersion. Within this presentation, the democratization of data should be considered, as many of the currently supported technologies are prohibitively expensive for most people. The following sections go into detail about the methodologies discussed above, culminating in a proposed workflow for the VA/VR project.

5.2.1 Step 1: The Background Information

It is incredibly important to have the background information in order to create an ethically responsible, accurate model for both interpretive and educational purposes. The information in Chapters 4 and 5 represents the background information necessary. There are several archaeologists who have developed the skills to create complex models on their own (e.g., Emanuel 2017, Richards-Risseto 2010, Vadala 2009, and von Schwerin 2013), and these forms of visualization are becoming increasingly popular tools within the discipline. Though this specialty is on the rise, many archeologists must still consult with outside 3D artists, software developers, or other 3D design specialists. However, the best way to ensure accuracy is to involve an archaeological visualization specialist in the project for an extended period. As another arm of an interdisciplinary archaeological team, visualizers would ideally work closely with the data acquisition process. Additionally, obtaining accurate background information on the site and prior research allows for the development of a better project plan. Topography, climate, and site conditions can provide barriers to certain methodologies, often requiring specialized equipment or alternative methodologies to become necessary. The more information that a researcher has available during the planning stages, the likelihood of success in collecting usable data is increased.

For this case study, I am fortunate to have joined the PCE research team and draw upon about a decade of professional field publications from which to derive data from, including field
reports to the National Institute of Anthropology and History in Mexico (particularly Glover and Rissolo 2010, 2015). These papers contain the interdisciplinary findings from the project, providing me with the information that I need to reconstruct the coastal shifts, vegetation, and archaeological context to model within the site. Additionally, as a member of the team, I was able to work in Mexico at the site and in the surrounding towns, meeting stakeholders and talking to locals about daily life. I also prepared for this project by spending a week at the research lab in Mexico working with materials from the site. In Jeffrey Glover’s graduate course in Mesoamerican Archaeology at Georgia State University, I focused my research on monumental architecture, visualization, and spatial analysis. While becoming more familiar with the associated groups and traditions of the area that I would be digitally recreating, I developed a better understanding of the stylistic changes, integrations, and representations over time.

For the Maya, finds like the Rosalila structure inform stylistic reconstructions (Figure 5-3), both in color scheme and detail. Dedicated on February 21, 571 CE, the building was later carefully preserved before it was buried. Other well-preserved examples of artistic style are found in murals, such as those discovered at San Bartolo, dating from the Late Formative Period, specifically around 100 BCE, showing the iconic red, black, white, and yellow color scheme (Figure 5-4) that adorns many reconstructions of Maya buildings (Miller 2012:70-73). Later examples of murals, still adhering to a similar color scheme, were found in Bonampak, and these depicted exterior and interior (Figure 5-5) scenes, providing lots of stylistic data for the Late Classic period, around 600 to 900 CE, from which they date (Miller 2012:194-198). At the Termanl Classic / Early Postclassic site (between 950 and 1500 CE) of Chichen Itza, a mural depicting the iconic talud-tablero architecture most typically associated with Early Classic Teotihuacan is juxtaposed against less ornate styles (Figure 5-6) representing regional stylistic
differences (Miller 2012:228-229). From these varied examples across time and the space of the
Maya world, general stylistic customs can be interpreted and applied to reconstructions. It is
also useful, when investigating iconographic evidence, to work closely with an art historian that
specializes in the area, as their insights may help determine differences in style (von Schwerin et
al. 2013).

Figure 5-3: A 3D Model of Rosalila Intended to be Viewed as a VR Experience
(Image from Chichcalan 2018)

Figure 5-4: San Bartolo Mural Showing Red, Yellow, White, and Black Color Scheme
(Image from Latin American Studies 1997)
5.2.1.1  Application to VA/VR

The case studies analyzed in Chapter 2 reveal that the most effective way to currently capture existent data for reconstruction is through using a laser scanner to generate a point-cloud
for later data processing and interpretation. Background information regarding the site, plus a personal site visit in December 2017, revealed dense vegetation covering the site. Owing to the dense forestation and the extensive lagoons and estuaries surrounding the majority of the island, the site provides many challenges to digitalization. Traditional methods of photogrammetric scanning would not be useful in an area of such dense vegetation. Even terrestrial lidar scans would generate dense and noisy point-clouds that would be inefficient to use. This, in conjunction with uneven topography and close proximity of the major site structures, created a situation where large-scale point-cloud creation would be nearly impossible.

Utilizing the data collected over years of study and reporting at Vista Alegre, as detailed in Chapter 4, the virtual reconstruction of Vista Alegre relies extensively on the archaeological surveys of the PCE team. Though only one personal site visit was possible leading up to this phase of the project, it was essential for understanding the particular needs for digitally reconstructing the site. The ideal methodology, based on the case studies examined in Chapter 2, requires LiDAR scanning to produce a dense point cloud that can be the foundation for both a terrain model and architectural 3D model. However, owing to the condition of the site, both structurally and in overgrowth, another method had to be found. Utilizing survey data collected for the site, volumetric models could be used as foundations for 3D modeling. At this point, I abandoned the idea of point-cloud modeling for this stage of the project and decided to use 3D modeling. I hope to incorporate point-clouds and spatial modeling at a later phase once the technology becomes more favorably adapted to the needs of the site.

5.2.2 Step 2: The Map

Maps are the spatial visualization foundation of any archaeological project. For 3D reconstruction, especially using 3D modeling, it is essential to have a map with GIS data for
elevation. Additionally, the main points of each structure that needs to be modeled need to also be correlated with the map. Luckily, collecting and assembling this data is already a standard practice in archaeology.

Research on this project at Vista Alegre began through an earlier, total station mapping project during Glover’s (2006) initial survey of the site in 2005 and has been added to in subsequent field seasons. For this project, the digital elevation models (DEM) and triangulated irregular networks (TIN) will be used to create a model of the landscape. These maps provide the terrain (Figure 5-7), and while Esri provides some 3D visualization tools through ArcScene, there are also methods to bring georeferenced data into Blender through an opensource plugin (see Appendix B). Modeling this in Blender using the elevation data allows for the models of the environment, structures, and terrain to be in the same program, adding to the consistency of the workflow. For people familiar with the artistic techniques of sculpting, like myself, this method also provides an intuitive way to work with computer graphics.
5.2.2.1 Application to VA/VR

The map (Figure 5-7), includes points indicating monumental architecture, excavation units, and features. This was created initially as a TIN vector image that needed to be converted to a raster image to be accepted into Blender, as this is the only filetype option available at this time. First, I calculated the elevation for the structures based off the highest point surveyed within the bounds of that structure. I represented this as an extruded basal layer. This will
provide the accurate, georeferenced foundation for future modeling in the Blender 3D modeling software. Next, I transitioned these data from a vector contour map into a raster image for use in Blender (Figure 5-8).

![Figure 5-8: Vista Alegre map, vector to raster to use in 3D modeling software as area foundation](image)

ArcScene provides some built-in features that automatically create limited 3D visualization, so I also changed the background to a sky blue and elevation levels to something more natural to the area (Figure 5-9). I added a layer for the wall that was discovered showing a potential boundary for the original use area of the site. Using ArcScene, I was able to look at a fly-through of the image, and I also exported the basic terrain as a 3D model as a .WRL format, the only export option.

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4 I opened this in Blender, shrunk the area by removing the flat plane outside of the wall feature, and I exported this as a .STL. I then used MakerPrint from MakerBot 3D printing to create a small scale model of the site. Owing to the relative flat terrain, the first attempt at printing failed and will need to be readdressed.
Next, using BlenderGIS, hosted on GitHub, I was able to import the contour shapefile into Blender, maintaining its original projection and georeferencing (NAD27, UTM 16N). I also imported the basal extrusion shapefile that I created earlier as a separate object. Once I rendered this as a mesh, I had a landscape foundation that is accurate and georeferenced from which to model my reconstruction (Figure 5-10). By using the basal extrusions, I am also able to begin modeling from an accurate volumetric block representing the elevation and footprint of each structure, providing the initial ‘clay’ from which the reconstructions will be molded within the 3D modeling software (Figure 5-11).
Figure 5-10: Blender screenshot of initial georeferenced elevation model

Figure 5-11: Blender screenshot of initial volumetric meshes
5.2.3 Step 3: The Model

Blender is used for the 3D modeling in this project, as it is a free, opensource product, and it is widely used in the 3D modeling community. Modeling software can be very intimidating, as it is a highly specialized field that is synonymous with Hollywood special effects teams, graphic designers, and high-end video game production. Though the same tools can be used at these higher levels, mastering the basics of 3D modeling allows for lots of archaeological
expression (see Appendix B for resources). As the workflow demonstrates in Figure 5-12, checks are built into the process of modeling to verify the archaeological integrity of the information being represented (Guidi et al. 2014:65). From the volumetric model, the structure is then established, refining the details to match the targeted design before the decorations and texture are added (Guidi et al. 2014). As this creates modular decorations that can be altered or removed as archaeological research produces new data, these are easily removed and reshaped (Figure 5-13). The buildings of Vista Alegre also lack many of the more decorative elements, as most of these structures were platforms for perishable structures.

Figure 5-13: Low Resolution Construction (A), Adding Details (B), and Adding Texture (C) to Structures in 3D Modeling. Note the modularity of the structural details. (Image from von Schwerin 2013:738)
5.2.3.1 Application to VA/VR

Creating the 3D architectural models for this site requires both the background information outlined in Section 4.3 and the accurate volumetric meshes created in the previous steps. Countless online tutorials and books can help the 3D modeling novice, and for this project, I relied heavily on YouTube and Udemy for the actual modeling (see Appendix B). The primary methods to create the models included basic mesh shaping and extruding. Structure 1, providing the most iconic shape, was the first that I decided to model. I created several versions of this structure (Figure 5-14), building from the footprint of the current state upward.

Figure 5-14: VA/VR model of Structure 1

Once I had the pyramid shape that I wanted, I returned Structure 1 to the surrounding context and situated it on the landscape in its correct location. At this point, I molded any terrain that interfered with the placement of the model. Using the elevation data collected by the BlenderGIS plugin and the original scale, I set the maximum height of the structure (Figure 5-16). I repeated this process for the remaining structures, though time constraints only allowed for Structure 2 to have tiering details that would have been evident on many of the larger structures. Using a similar process, I also created the wall along the southern perimeter of the
site, using the changes in elevation and topography as a guide for placing the reconstructed shape.

Figure 5-15: Using BlenderGIS for modeling scale

Figure 5-16: Primary structures on terrain reconstruction in Blender
5.2.4 Step 4: The Texture

The texture for 3D modeling is the visible surface of the terrain, the objects, and the sky. Just as with other parts of this process, there are many ways to obtain these data. Some projects with relatively clear site centers can gain a lot of feature detail from using satellite imagery or drone imagery, even using photos to create some of the detail. Owing to the tree coverage at Vista Alegre, photographs and point-cloud data will make excellent reference material, though they will not be able to be used directly in the model.

Drawing from the paleocoastline reconstruction work that has been done at the site will provide the necessary information to model the changes to the landscape in the time between the modern mapped terrain and the eras that Vista Alegre was occupied (Jaijel et al. 2018). Work has also been done at the site to reconstruct the varieties of vegetation and wildlife present during the periods of use. In addition, data from well-preserved sources, as discussed in section 5.2.1, add the color detail for the models. It bears noting that it is important to connect the modeled era with the correct associations; when representing a site at a particular point in time, the materials used to inform the model must also come from a close time and place. Stylistic change over time is a foundational understanding of archaeological inquiry, so we must make sure to represent it accurately in our reconstructions.

5.2.4.1 Application to VA/VR

My initial idea for this project was to create my own textures based on the site, but time constraints led me to using my personal reconnaissance photographs as reference images to find textures created by artists online (see Appendix B). One of the textures that I acquired for this project was a programmatic terrain texture generator called True Terrain that uses data such as porosity, elevation, geographic location, and groundwater levels to create landscape coloring
(Figures 5-17 and 5-18). I also acquired various textures for vegetation, plaster, stone, wood, and sky from sources listed in Appendix B to use on the models. Using a technique called Baking, I UV unwrapped (or made my 3D objects 2D) my structures and applied textures, attempting to match styles that would have been found during Vista Alegre’s structural apex (Figure 5-19).

However, a problem arose late into the project in exporting the material files; the textures simply would not show up. I tried exporting to every type of 3D file that Blender can encode, but at the time of this writing, the only place to view the textures as they are rendered is within the software of Blender itself using the Cycles Renderer. The current version of VA/VR circulating relating to this thesis is bare of any color. This is the first thing that I plan on addressing in the next stage of this project’s development. Viewing the structures without color does have an interesting effect and will be discussed further below.

![Figure 5-17: Vista Alegre textured with True Terrain (top) Including (right) node-based options (see Appendix B)](image-url)
5.2.5 Step 5: The Platform and Presentation

Once the assets are all created, they can be brought into a 3D rendering program to build the user interface necessary for interaction, and often, a gaming engine is used for this. There are
many options for gaming engines; the commercially successful Unreal engine and the opensource project Unity are two of the most popular. Future versions of internet browsers will begin to have VR viewers built into them, so soon, anyone with a headset and good internet access will be able to view any VR content streaming on the internet (Mozilla 2018). This is the democratizing idea of WebVR, bridging accessibility and affordability by utilizing the existing infrastructure. Headset technology is also changing, becoming less expensive and more widely available for both viewing and interaction. Currently, anyone with a smartphone can create a viewer out of cardboard that interacts with certain VR applications. Demand for inexpensive headsets will increase as WebVR offers increase, and these will initially be created as viewing experiences requiring less hardware to track movement allowing for a market under the range of current Oculus and Vive headsets that cost hundreds of dollars. This project initially compiles the assets in Unity, as it is free and opensource, but the assets will also be stored as discrete units within a repository so that they can be used in WebVR as soon as that becomes widely available (e.g., https://aframe.io/examples/showcase/helloworld/). The goal is to offer multiple platforms to access the VR recreation of Vista Alegre, from the high-end Oculus and Vive viewers to a version that can be viewed through simple affordable viewers in tandem with smartphones. Google Cardboard does offer an approach to an affordable VR viewer that requires a compatible smartphone, for example.

5.2.5.1 Application to VA/VR

Initially, VA/VR was designed to be a set of discrete assets that could be incorporated into many different platforms with minimal remodeling. For example, Structure 1 would exist as a singular entity, such as shown in CyArk’s in Figure 2-16 (though created with different methods), encoded with its geolocational data in a visual database so that it could be used in VR,
AR, or other mixed reality supported systems without having to recreate it. The primary use of the assets would be to create an Oculus-based VR experience for this thesis phase of the project. To this end, I succeeded, however I was not able to model the quantity of structures to the detail aspired to. Owing to time constraints, I was not able to familiarize myself sufficiently with Unity’s graphics engine to create a game-like user interface as originally intended. Currently, the model can be experienced in VR in a developmental WebVR framework (Figure 5-20), such as hosted by Google Poly (https://poly.google.com/). Owing to the instability of this currently, and the issues with my textures not rendering, I presented the final project using IrisVR (https://irisvr.com/), a commercial product that hosts VR models with an immersive user interface. During development, this framework functions. However, this is not sustainable long term. Once the model is to a place for public dissemination, a new medium will need to be selected for exhibiting the model.

![VA/VR viewed in WebVR hosted on Google Poly without texture](image)

Owing to the proposal of the community museum, I have reevaluated a lot of the original intended use of this project. The museum proposes to host a variety of artifacts, informational panels about the cultural and natural resources of the north coast, short documentary videos of
recent archaeological work and area history, and outdoor interactive exhibits (Glover et al. 2018b). Full immersion VR for this type of community museum is unsuitable owing to the self-guided nature of exhibition experience (Glover et al. 2018b). The most sustainable initial solution for this space is to develop the model for use on an interactive, touchscreen display, allowing for the reconstruction to be viewed on a 2D display. Working in conjunction with this display would be a smartphone application that would be compatible with a Google Cardboard-type viewer. This could be downloaded from a QR code posted alongside the museum installation. This app would provide the same experience as the touchscreen, but it would also extend into personal VR. This same app could be extended to local school children through an outreach program developed in tandem with the community. These and further possibilities are discussed further in Chapter 7.

5.3 Visualizing Future Stages of the Model

A main challenge of archaeological display for public consumption is to provide adequate context for a non-specialist audience while not misrepresenting the past. This balance between authenticity, representation, and education is made difficult due to the inherently incomplete archaeological and historical records. This often leads to an oversimplification of presented material or the tendency to need to choose one history to represent out of the palimpsest of a site (Stone 1997). As museum resources are limited, and the spatial restrictions of display areas often dictate the style of exhibition, museums are also constrained as to what they are able to show and how often the contextual information can change to reflect ongoing research. VR and AR technologies, integrated with the standards of museum display practice or as self-contained educational tools, offer solutions to many of these problems or challenges. As materials are digital within these formats, they take very few resources to update or maintain as new
information emerges. Additionally, much more material can be connected visually within a display than in traditional exhibitions. Videos, audio, maps, links between objects and sites, and experiential interaction are now possible to present within a virtual environment connected to an artifact, feature, or site. Places can be shown during different construction and occupation phases to represent change over time, further contextualizing archaeological and historical data. The goal now is to determine how to best use these technologies through understanding the potential problems that could arise. We must examine how interpretation through these technologies can give rise to the ability to ask new questions, inspire theoretical development within the discipline, while educating and exciting the public about the benefits of archaeological and anthropological education in addition to the relevance of archaeology to the contemporary world.

The final product of this visualization will be a three-part project. First, the assets will be used in the VR reconstruction of Vista Alegre as described above. This form of immersive visualization can allow for people who have not visited the site to see it remotely and at different stages through its occupation with the right equipment while in the classroom, in the home, or in a museum. Second, these assets will also be connected to an online visual database that will act as a virtual exhibit using Omeka. As Omeka can be accessed through the internet, this will allow the public greater access to the educational materials associated with the site. This form of virtual exhibit can utilize the 3D objects, placing them in context with descriptive data and other documentary forms of information. Third, as these assets will be georeferenced, they can be used for AR applications, such as seen in the work of Jeff Emanuel (2017). Using a handheld device at the site of Vista Alegre, these assets could be viewed in their preexistent locations. As it is a remote location with no site-based tourism, the public access and educational component
of the project includes an upcoming museum project in the port city of Chiquilá. Building a visualization for this museum exhibit couples with the initial goal of this visualization as an interpretive research tool within the project and to acquaint incoming members of the project with the area.

A final, and future, goal of this visualization is to build on the work of archaeologists specializing in educational gamification (e.g., Bryant 2015, Dean and Nichol 1984, Reinhard 2018, among many others) and explore the possibilities of gamification within the project, both in public education and in local civic engagement. Within a local museum setting, such as one that has been proposed in Chiquilá, gamification of the virtual environment would not only teach tourists and locals about the history of the area, it would also engage the mind in critical thinking through exploration and puzzle-solving. When people are inspired to care through education, empathy, and understanding, and when they can create a memory out of a relatable experience, they are more likely to act. This kind of education can drive directed change, creating emotional connections and encouraging actions towards heritage preservation.
6 PRAXIS AND THE FUTURE

Within anthropological and archaeological theory, technology is often seen as a prime mover of cultural and social change. What society has experienced since the era of personal computing and the internet began reveals that we are living in a time of radical social change enabled, in part, by the opportunities that have been created through increased global connectedness. Many of these opportunities have been used to perpetuate existing social inequities, often unconsciously, owing to embedded systems of institutionalized marginalization (e.g., any social media site). As such, theory and ethics must be enacted when engaging these technologies in research or public education to mitigate any unanticipated negative consequences. A praxis-based approach, as defined in Chapter 3, to theory and application with these technologies is essential, both to maintain ethical and responsible practice standards but also to critically assess the assumptions, outcomes, and uses to increase the effectiveness of these technologies going forward. These questions drive the critical and theoretical advancement of the discipline. Into this framework, the technologies of VR and AR offer new ways to engage with anthropological and archaeological data through experiential immersion. With these pedagogical practices, new questions continue to emerge that need to be critically addressed, such as how to best represent the people and material left behind, how to engage and educate the public, and where to draw the line between accuracy and experiential quality.

6.1 Findings and Effects on Theory

These shifts in visualization allow for both researchers and the public to interact with visual data in new, more substantial ways. 3D visualizations have been able to answer many questions through quantitative analysis that we have only been able to qualitatively assess or hypothesize about prior to this technology’s use. For example, Vadala (2009) uses his
reconstruction of T’isil to test accepted spatial usage models, ritual cenote-use hypotheses, and proposed cosmological alignments in T’isil. Through viewshed analysis and using an accurate celestial simulation, Vadala can quantitatively measure the paths of the sun, moon, and other celestial bodies in relationship to the site layout, testing currently accepted hypotheses that lack quantifiable data. This methodology builds upon a long legacy of tracking celestial alignment of Neolithic henge monuments in the UK (e.g., Higginbottom et al. 2015). Vadala also extends this methodology and VR interface for researching Maya caching practices through Actor-Network theory (Vadala 2016). Graham Goodwin and Heather Richards-Rissetto (2017), working at Copán, analyzes the acoustic properties of the built environment to gain insight into the use of sound in large ritual events. Through the immersive recreation, Goodwin and Richards-Rissetto have obtained quantitative and qualitative data about acoustic data that could only be assumed before. These questions not only highlight the role of the spatial environment within archaeological interpretation, but the ways in which these spaces play recursive roles with various social agents. This connection helps archaeologists understand how ritual practices and ideology help constitute past social identities. These interpretations are leading us as researchers to a better understanding of the past, and these technologies are providing us with more immersive, entertaining, and engaging ways to present this information to the public. In all, this technology both produces more accurate data and makes the data more accessible to the general public.

These new forms of visualization are progressing the questions that we are asking regarding public involvement and education of interpreting history and the archaeological process. Robert Bryant (2015) proposes using crowdsourcing techniques and gamification to further civic involvement with Georgia State University’s Phoenix Project, a project headed by
Glover to reanalyze archaeological materials recovered from the MARTA (Metropolitan Atlanta Rapid Transit Authority) excavations in the late 1970s. Gamification within archaeological presentation has shown to have commercial interest, as seen in the popular historically themed game franchises *Tomb Raider* and *Assassin’s Creed*. Applying puzzle-solving and exploration themes within a virtual environment creates a connection through the memory of experiencing the place. This connection, when fostered through a praxis-based visualization framework, can lead to increased civic engagement, empathy, and understanding of cultural heritage preservation.

Though we are able to more accurately and quantitatively assess aspects of archaeological research using these new techniques, Thomas G. Whitley (2017) argues that to call something a theoretical ‘paradigm-shifter’, we must ask new questions and fundamentally change the way that we see humanity of the past and today based on these visualizations. One of the cornerstones of a praxis-based approach is also the ability for research to have a practical application that feeds back into theoretical critiques (Kozaitis 1997), and as I am proposing a praxis-based approach to archaeological visualization through VR, this critical feedback is a very important element to my methodology. With this technology, we are able to approach the foundational issues of archaeological research in new ways. We have new ways to address questions of accuracy, representation, and construction, just as we are able to supply new data for the interpretation of spatial use, acoustics, and many other subjects. In viewing VR and AR visualization through Whitley’s (2017) understanding of a theoretical paradigm-shifter, we see that this technology is allowing us to answer new questions, but we should also use this new data to work on the theoretical issues that we have always been concerned with but have yet to find the resources to substantially quantify or address, such as revisiting inquires into population
count, paths of movement, and the phenomenological experience of these sites. We are constantly refining our theoretical approaches with the invention of new technologies, often circling back to older ideas with new information. In archaeology this is especially important, as we are the only discipline to destroy “our informant” through our inquiries, so the gathering and preservation of uninterpreted data takes on a greater importance.

6.2 Archaeological Praxis and Virtual Worlds

The democratization of archaeological and cultural heritage data in the form of visualizations allows for people to connect to a shared continuity of historical identity, highlighting our connections to interwoven backgrounds, traditions, and ideology; the study of these connections to the past allows us to make informed decisions about the future (Little 2002:4). As a scientific, problem-oriented, and evidence-based discipline, studying archaeology enhances critical thinking skills. Interpretations of archaeological materials are also uniquely suited to question assumptions about the past. Archaeology has the ability and power to challenge the rewriting of history by dominant political structures over time, revealing the complex truths of our past (McGuire 2008). Creating the understanding in individuals that knowledge is always filtered through a social and political lens reveals the need for critical approaches to taking action within the world rather than just blindly building on the assumptions of the past. Democratizing VR visualization for use in classrooms, especially within marginalized communities, can allow exposure to global arenas previously only available to those with the means to travel internationally. Enhancing the skills of critical thinking and expanding the worldview of students, especially in their youth, has the power to create excitement and wonder that can drive community engagement and direct change.
It is also important to prioritize use of these technologies and forms of visualization in underserved or historically disenfranchised communities who are further removed from the possibility of international travel. By exposing more of the population to cultural heritage visualizations, we can create memorable experiences that can become the catalyst for connections with locations and with history. Informed connections inspire change through action. Creating this participatory, directed change is the core of praxis (Kozaitis 1997).

Informed community engagement is at the heart of archaeological praxis, and this is first achieved through education (McGuire 2008). Community engagement does not simply mean educating the public and hoping that they will act; it is a curated experience that drives active engagement to confront systemic issues (Mullings 2007). Archaeological praxis provides insight into the systems of structural violence, their historical origins, and their resulting assumptions, especially in regard to historically marginalized communities (Mullings 2007). Creating awareness and educational platforms around these issues allows for the confrontation of assumptions, generating a more informed public. Emancipatory praxis within an archaeological setting aims to remove many of these assumptions, allowing for marginalized communities to reclaim an identity more closely aligned to their historical heritage and based less on politicized historical narratives (McGuire 2008). This is also a form of restorative justice, providing voices to those silenced through a historical narrative of oppression, as demonstrated in many of the emic views provided by post-processualist alternative archaeologies, such as indigenous, feminist, Marxist, and critical archaeology (McGuire 2008).

AR and VR technologies can aid in this restorative justice, as they can animate the past in dynamic visualizations in lieu of static objects by providing a voice and agency to the people of
the past instead of representing them as silent mannequins\(^5\). Of course, in a praxis-based approach, this must be conducted in a representative and informed manner, involving community partners within the interpretive process (Kozaitis 1997). This form of collaborative research can lead to a holistic presentation which educates and unifies collective awareness about the realities of injustice, and this awareness can create collective agency that can enact real directed change in the world (Kozaitis 1997; McGuire 2008). This can of course become complicated when various stakeholders have competing interests (e.g., Glover et al. 2012).

Through his graduate work at Georgia State University and subsequent collaborations with Emory University, Robert Bryant (2015) explored the role of gamification within archaeological presentation to better encourage the public towards civic engagement. As this is the kind of directed change that praxis demands, incorporating some of these ideas into the VA/VR project will add greater ethical importance to the visualization. Creating the rules of a game, especially one that encourages the player to take on the role of an indigenous inhabitant of the site, allows for the player to navigate through the space with purpose and a better understanding of the resources, networks, and limitations of life during that time and place. Bryant extended these ideas alongside other researchers forming the Samothracian Network (2018) at Emory, created to develop a game based on maritime trade. As Vista Alegre was a coastal trading center, and archaeological interpretation has found to have a varied and complicated association with the large Maya site of Conil, with broader interactions extending from Honduras to the Gulf of Mexico, building a game based on the interactions of these places would provide greater context and enjoyment for the public when engaging with this material.

\(^5\) However, there are some notable exceptions that expand the patterns of museum display, such as recent installations addressing the plight of refugees.
VR and AR presentations are active pedogeological tools that engage the public in this way, rousing empathy and awareness of the past where we can identify and learn from the successes and failures of history. This technology also leads to adaptive learning which is also critical for education as social justice (Kozaitis 1997). Through collaborative work with the community and indigenous populations, these give an active voice to the past and the current inhabitants of an area, while also creating meaningful connections with the public.

6.3 Visualizing Praxis with VA/VR

It is unethical to use technology to help solve problems afflicting a community without also including a sustainable plan for the use of that technology co-created with the targeted community. For VA/VR to achieve its goals of praxis, it needs to directly benefit the most vulnerable members of the community, in this case, the local children. Even though many of the local children are not from indigenous Maya homes, they are still connected to these sites as they grew up near them. Additionally, it is important to educate the local children, as they will likely be the future caretakers of these cultural resources, potentially benefiting from them emotionally and economically. Even if the archaeological sites are primarily seen as potential financial resources, they have a value communicated around them, and this value grows with the development of a stronger personal connection through education. Aiming educational programs that extend beyond the museum that directly relate to these children could provide the opportunity for VA/VR to fulfill its goals of providing fully immersive educational tools to the community.

The first step towards this goal would be to identify a target school to work with. Understanding the teaching styles and available resources of the educators provides much of the essential information to identify a need and successfully address it without disrupting the
elements of the system that are working well. I would want to observe classes and participate in discussions with the teachers, students, and parents about educational techniques; what they feel is helpful, what is enjoyable, what is lacking. Ideally, accompanying the class on field trips to local archaeological sites would be helpful to understand the focus of the children and direction of the instructors, if the opportunity was available. If trips of this nature were not available, why not? Is it is resource constraint or something else? Again, the only way to truly understand the potential benefits and consequences of introducing an unfamiliar technological operation is to have first person interactions with the system and agents in place.

As far as hardware availability, there has been some interesting commercial ventures into mobile VR busses and other types of rentals, but to create a long-term plan, the hardware utilized must be maintainable and familiar to community members involved with the project, at the very least. Smartphones offer a familiar interface to many people, and there is little additional equipment necessary to charge and maintain these. The second step in this would be to acquire the hardware, ideally through a relationship developed with a phone manufacturer, reseller, or tech company. Extending a partnership for the project to include corporate backing not only opens up the resources available through funding (in exchange for some good publicity, often benefiting both the company and the project), but also creates opportunities for those inside corporations to connect with community beneficiaries, expanding the worldview of those linked through these connections. Many technologies companies value educating marginalized communities as a way to democratize development opportunities (e.g., GitHub’s Social Impact division, Gates Foundation, Google Ideas, among others). Seeking out partnerships with companies that provide the resources to develop and disseminate affordable VR solutions within a community could be a serious benefit for the future of this project.
The third step in this goal would be to work with the chosen school, those associated with the upcoming community museum, and the members of PCE to create a public interface application that would be available in major app stores for VA/VR. This would include all of the primary goals of the project, acting as a public ingress for information on Vista Alegre. This would combine elements of the museum, such as reformatting the information panels for web-use and showing 3D models of various artifacts, in addition to the interactive virtual model of a reconstructed Vista Alegre, viewable through a homemade cardboard smartphone holder.

Updates and maintenance on the remote classroom devices would be just as necessary as maintaining the museum. This would need to be incorporated into the development of this project. If these two systems were hosted together, therefore tying together the updates of their software, it would ensure that the mobile devices would have the same access as the museum to technical upkeep. This is just an outline of the early stages of a praxis-based program to extend VA/VR’s audience outside of the museum and into the immersive. Many more considerations would have to be taken into account prior to the initiation for any such program. The basis for this thesis could provide adequate foundation for future grant applications, and this is one of the goals discussed further in the conclusions.
7 CONCLUSIONS

The goal of archaeology is to present the lifeways of past people as accurately as we can interpret these from the material remains left behind, and the discipline is continuously grappling with the understanding that interpretations are filtered through socially constructed biases and cognitive structures (Trigger 2006:484-528). Remaining aware of this is a first step towards removing potential layers of interpretive fallacy to better represent the past. In presenting this material, visualization of features, sites, and artifacts become the strongest way to represent findings of archaeological investigation, as they allow for more empirical and individual interpretation as opposed to the often singular-vocality of descriptive interpretations (Stone 1997). However, reconstructions do raise other questions regarding accuracy of interpretation. Though questions of accuracy in archaeological interpretation are not new, the ways that we now address and mitigate these issues open new paths for development in both theory and practice.

7.1 Critiques

If I were to start this project over, I would have examined Vadala’s (2009, 2016) work more extensively and at an earlier point, as his methodology and situation ended up providing the most direct corollary to how I approached VA/VR. Discovering the similarities earlier in the process of researching this project would have allowed me more time to develop the model in lieu of continuing to research multitudes of methodologies. That said, I am grateful for the opportunity to explore many of these other methodologies, as each situation demands its own unique tools and adaptations, and through exploring these further in the paper, I feel more comfortable and confident about many of these approaches.

On this same topic, I would have started from a more familiar place with the site of Vista Alegre. I waited until later in the process of developing the model to truly understand the
nuanced nature of the occupational history and archaeological data collected at the site. My time working in the lab and visiting the site added greatly to my understanding, but nothing can replace time spent in the area after extensive research. I can only blame myself; I waited until after my field seasons to really dive into the past excavation data, which resulted in a less connected association with the site than I should have. Despite my project extolling the value of the immersive experience and direct connection to knowledge, I waited until after I had the experience of being at the site to explore the literature. I can directly relate now to how much I missed from combining the accumulated archaeological knowledge directly with the site while I was there. At least I can carry this lesson forward, making sure to provide contextual information before and directly related to the site to maximize its didactic value.

As a final commentary, I wish to discourage anyone else from attempting to learn the more advanced aspects of a software application as a component to their thesis unless they provide themselves with adequate time. It took me an unexpected extra semester, and I still did not get the project as far as I would have liked. Though familiar with Blender, I underestimated the requirements of scientific rigor and striving towards accuracy that is not generally an issue in creative work. I often found my modeling subject to the limitations of my skills within the program, and I felt myself taking more interpretive leaps based on the geometry of the software than I expected. Additionally, as with almost any technology, there are the inevitable issues of exporting, conversion, saving, and just the basic learning curve of the software. Overall, this project was a beautiful struggle, but these few things could have added greatly to my efficiency.

7.2 Plan Going Forward

In many places throughout this project, I have elaborated on areas that could be expanded and future goals that I wish to pursue. I often conflate possibility with goal, resulting in an
overwhelming and frequently impossible quantity of objectives to achieve on any given project, especially if I am as excited about the potential of the execution as I am with VA/VR. Owing to this, it is important that I directly identify my next immediate steps for the model, as having a clear plan negates many of the ill effects of my enthusiasm.

The first goal is to finish the model, making it fully representative of a reconstruction of the site. This includes adding the impermanent structures, correct textures, and rendering the plaster in the red most used on Maya structures during this time. Once the reconstruction has been fully generated and checked by the PCE team, the next goal is to prepare this for potential inclusion in the museum. Owing to the connections necessary to begin this process, this would also be an ideal time to start the praxis-based implementation of the model into the surrounding school systems, based off the outline provided in Section 6.3. If possible, supporting a bridge between the museum and classrooms early on, depending on the stakeholder goals for the museum, may afford opportunities within the community otherwise unavailable. This leads into the next step, developing the app that would exist concurrently with the museum exhibit.

7.3 Discussion and Concluding Points

Visualization is, at its core, a communication device, and the goal of any visualization project should be creating the clearest form of communication possible. Many of the praxis-based applications of archaeological presentation have been developed further within the burgeoning field of Digital Humanities. This interdisciplinary field of study has much in common with archaeology, especially in the forms of visualization used by both (Earley-Spadoni 2017). Clearly, there are many criticisms and avenues of improvement for archaeological material display, such as representing contested territory or shifts in ownership over time, increasing multivocality in presentation and education, and increasing involvement with and
representation of indigenous communities. I agree with Tiffany Earley-Spadoni (2017) in her assessment to look at the work done in Digital Humanities, specifically the practice known as deep mapping, allows for digital storytelling to be told spatially and chronologically, and this is something that is very applicable for the archaeological discipline. Additionally, the Digital Humanities are currently a well-funded discipline, and archaeologists should expand their skill-sets to include education in digital humanities due to the increased access to resources that are currently available to practitioners (Earley-Spadoni 2017). There are possible barriers to such an interdisciplinary expansion for archaeologists, however, such as the lack of tenure track recognition for academic archaeologists work within digital humanities and the current technological barriers that accompany attempting to present complex visualizations of data in a traditionally 2D format (Earley-Spadoni 2017). Recognizing these problems is the first step towards creating solutions, and as more researchers engage in collaborative activity with technology, the more obvious the benefits will become.

Through an interdisciplinary, praxis-based approach to visualization in archaeology, these pedagogical tools can expand from communicative and informational platforms into the realm of directed change towards a better-informed public. The benefits of immersive education, through the construction of personal connection and mutual understanding, are well suited for application within the discipline of archaeology and address current critiques of presentational methodology. The creation of VR and AR content for public consumption expands the interdisciplinary scope of archaeological education into the realms of anthropological thought and critical thinking, creating a more informed and empathetic public. As the democratization of this technology continues, future use of this form of visualization will stretch to provide
experiential content to many people who would not otherwise be able to visit these sites, museums, or have access to this cultural education.
REFERENCES

3D Atlanta

Al-Jabarti, Abd al-Rahman

Ancient Invisible Cities

Anderson, Michael

Asociacion Copán

BBC World News

Beddows, Patricia A., Jeffrey B. Glover, Dominique Rissolo, Alice M. Carter, Roy Jaijel, Derek Smith, and Beverly Goodman
2016 The Proyecto Costa Escondida: Recent interdisciplinary research in search of freshwater along the North Coast of Quintana Roo, Mexico. *WIREs Water* 3:749-761.

Bonde, Sheila and Stephen Houston

Boon, James A.

Bourdieu, Pierre

Bryant, Robert

Cameron, Oliver

Cauty, Andrex

Chichalan

Coe, Michael D.

CONAMP

Counts Jr., Edward L.

CyArk

Dean, J. and J. Nichol

Delgado, Carlos

Detroit Institute of Art
Earley-Spadoni, Tiffany

Eisler, J., J. Pejša and K. Preuss

Emanuel, Jeff

Ervin, Alexander M.

Fash, Barbara W. and William L. Fash

Felix and Paul Studios

Flickr


Gagnon, Bernard

Gentil, Verna
2017 Exploring Settlement Patterns at the Ancient Maya Port Site of Conil, Quintana Roo, Mexico, Master’s Thesis, Department of Anthropology, Georgia State University, Atlanta.

Glover, Jeffrey B.

Glover, Jeffrey B., Zachary X. Hruby, Dominique Rissolo, Joseph W. Ball, Michael D. Glascock, and M. Steven Shackley

Glover, Jeffrey B. and Dominique Rissolo
2010 *El Proyecto Costa Escondida: Una Investigación Arqueológica del Puerto Mayal, Quintana Roo, México (English version).* Informe Técnico Anual al Consejo de Arqueología del Instituto Nacional de Antropología e Historia, Mexico City.


Glover, Jeffrey B., Dominique Rissolo, Joseph W. Ball, and Fabio E. Amador
2011 Who were the Middle Preclassic settlers of Quintana Roo’s north coast? New evidence from Vista Alegre. *Mexicon* 33(3):69-73

Glover, Jeffrey B., Dominique Rissolo, Nathania Martinez, Mikaela Razo, Carlos Cisneros, and Timothy Murtha
2018b Chiquila distrito del patrimonio cultural y natural museo comunitario. Manuscript on file with PCE and Anthropology Department in care of Jeffrey Glover, Georgia State University, Atlanta, GA.

Glover, Jeffrey B., Dominique Rissolo, Jennifer P. Mathews, and Carrie A. Furman

Goodwin, Graham and Heather Richards-Rissetto

Guidi, Gabriele, Michele Russo, and Davide Angheleddu

Harris, Marvin

Higginbottom, Gail, Andrew G. K. Smith, and P. Tonner

Huggett, Jeremy

Jaijel, Roy, Jeffrey B. Glover, Dominique Rissolo, Patricia A. Beddows, Derek Smith, Zvi Ben-Avraham, and Beverly Goodman Tchernov

Kantner, John

Kirshenblatt-Gimblett, Barbara

Klynne, Allan

Kozaitis, Kathryn A.
1997  The Rise of Anthropological Praxis. In The Unity of Theory and Practice in


Latin American Studies

Lavine, Steven D. and Ivan Karp

Latour, Bruno and Steve Woolgar

Linda Hall Library

Little, Barbara J.

McGuire, Randall H.

MayaArch3D

Miller, Mary Ellen

Miller, Paul

Mozilla
Mudge, Mark, Tom Malzbender, Alan Chalmers, Roberto Scopigno, James Davis, Oliver Wang, Prabath Gunawardane, Michael Ashley, Martin Doerr, Alberto Proenca, João Barbosa

Mullings, Paul R.

Ortner, Sherry

Oxford Handbooks Online

Pujol, Laia

Prins, Adam B., Matthew J. Adams, Robert S. Homsher, and Michael Ashley

Proskouriakoff, Tatiana

Realities.IO

Reilly, Paul

Richards-Rissetto, Heather

2013 From Mounds to Maps to Models: Visualizing Ancient Architecture Across Landscapes. Anthropology Faculty Publications, Paper 64, University of Nebraska, Lincoln.


Tokovinine, Alexandre

Trigger, Bruce G.

UNESCO

Vadala, Jeffrey

2016 Analysis of Ancient Maya Caching Events at Cerro Maya (Cerros), Belize: Assemblages of Actor-Networks, Temporality and Social Fields in the Late Preclassic Period. PhD Dissertation, Department of Anthropology, University of Florida, Gainesville.

Vance, Erik

von Schwerin, Jennifer, Heather Richards-Rissetto, Fabio Remondino, Giorgio Agugiaro, and Gabrio Girardi

Wallerstein, Immanuel

Whitley, Thomas G.

Wolf, Eric

Worley, Will
2016 Palmyra: Photographer's powerful before and after photos show city's destruction at hands of Isis. Independent, April 2, 2016, Electronic Document,

Zwegars, Arian
2013 Muyil, Structure 8I-13, Castillo, Electronic Document,
APPENDICES

Appendix A: Technical Glossary

**3D Modeling**: a form of computer graphic creation using virtual ‘clay’ to mold objects from ‘primitives’, or basic shapes, using software (such as Blender, Maya, or Z-brush among others)

**3D Scanning**: a form of data collection using lasers to bounce light off surfaces to digitally reconstruct a quantifiably-based digital reconstruction of a surface- requires a laser scanner and processing software

**3D Objects**: digital objects resulting from 3D modeling or 3D scanning (among other data capture methods), often with the file format of .OBJ, .GLTF, .DAE, and WRL among many others

**Augmented Reality (AR)**: a type of digital visualization relying on a transparent lens overlay, such as glasses or through a smartphone’s camera lens, that uses height and depth calculation to add 3D digital objects into the user’s natural field of view. Popular examples include Google Glass (hardware), AR shopping options (online option), and PokemonGo (software)

**Digitalization**: this term can have a variety of meanings, but for the purposes of this paper, digitalization refers to the process of digitally representing materials from the real world in a simulated, computer-based environment

**Game Engine**: there are a variety of game engines, such as Unity and Unreal, and the purpose of these is to render the locations of 3D objects, lights, surfaces, and the related physics of these objects (collectively called a scene) and create a user interface that allows the scene to be interacted with by an end user through controls (often mouse/ keyboard or controller-based)

**LiDAR**: also referred to as ‘Lidar’, can be correlated with ‘light radar’, and this data collection tool uses light to image objects through measuring distance and by targeting specific materials- it
is a desirable tool for survey and digitalization work, and can be used on the ground or attached to an aircraft or drone.

**Open Source:** open-source software makes the original code constructing the software openly available for distribution or modification, allowing for software to be freely shared and added to by the community through a content control service such as GitHub.

**Photogrammetry:** a data collection process where digital photographs of high resolution are taken of a surface, terrain, or object with at least 80% overlap, then processed in software, such as Agisoft Photoscan, to create 3D models based on algorithms defining spatial points of relationship between the collection of photos, creating a point-cloud of the target.

**Point-cloud:** point-clouds are the results of 3D scanning, photogrammetry, and other types of quantitative-based 3D modeling technique, revealing only the data points used to construct the model- dense point-clouds (owing to their high resolution) offer the texture and color data of the object and render faster in software, often making them a more preferable viewing method than the solid textured meshes that often result from fully rendered point-clouds (see Figure 2-21).

**Textured Mesh:** the result of point-cloud based or 3D modeling-based data being rendered, or made ready to view outside of the software used to create the image.

**Virtual Reality (VR):** a type of digital visualization that isolates the user from their natural field of view and soundscape, replacing it with an entirely digital 3D experience through use of a visor or other headgear. Popular examples include Oculus Rift (hardware), HTC Vive (hardware), Playstation VR (hardware), and hundreds of educational and entertaining software options.

**WebVR:** VR that is hosted through compatible web browsers for a variety of headsets from Cardboard to Oculus Rift and HTC Vive.
Appendix B: Online Tutorial Resources

I. Tutorials
   a. YouTube
      i. Andrew Price: Blender Guru
         (https://www.youtube.com/user/AndrewPPrice)
      ii. Blender Foundation (https://www.youtube.com/user/BlenderFoundation)
   b. Udemy
      i. Ben Tristem: 3D Model Introduction- Preparing Blender Models for Upload
         (https://www.udemy.com/unityassets/learn/v4/content)
      ii. Rob Tuytel: Creating 3D Environments in Blender
         (https://www.udemy.com/blender-environments/learn/v4/overview)

II. Plugins
   a. Blender GIS
      i. https://github.com/domlysz/BlenderGIS
   b. Blender Sculpting Tools
      i. https://github.com/MadMinstrel/blender-sculpt-tools
   c. Google Open Maps
      i. https://github.com/vvoovv/blender-osm

III. Textures and Models
   a. Terrain
      i. https://blendermarket.com/products/true-terrain
      ii. https://www.poliigon.com/
   b. Tropical Plants
      i. https://blendermarket.com/products/tropical-plants
   c. Stones
      ii. https://www.poliigon.com/